CERES Cloud Working Group Report

CERES Science Team Mtg., Virtual, 28-30 April 2020

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E. Heckert (web), B. Shan (GEO), R. Smith (web, NPP), D. Spangenberg (everything), Churngwei Chu (web), Zhujun Li (val)

SSAI, Hampton, VA

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P. Yang (ice models), Texas A& M University

X. Dong, B. Xi, (validation), University of Arizona

Thanks to Dave Doelling and his TISA/calibration teams!

Topics

- Processing Status
  - Update on NPP Ed2 and NOAA-20 Ed1
- Edition 5: status and plans
- GOES-17 update

Update of CERES Cloud-related Papers (2020)

Edition-4 References (https://satcorps.larc.nasa.gov/cgi-bin/site/stub-CERES-algorithms?cmd=references&ed=4)

S. Sun-Mack, P. Minnis, Y. Chen, D. R. Doelling, B. Scarino, C. O. Haney, and W. L. Smith, Jr., 2018: Calibration changes to Terra MODIS Collection-5 radiances for CERES Edition 4 cloud retrievals. IEEE Trans. Geosci. Remote Sens., 56, 6016-6032, doi:10.1109/TGRS.2018.2829902 **ED4 CALIBRATION**

Trepte, Q. Z., P. Minnis, S. Sun-Mack, C. R. Yost, Y. Chen, Z. Jin, G. Hong, F.-L. Chang, W. L. Smith, Jr., K. Bedka, T.L. Chee, 2019: Global cloud detection for CERES Edition 4 using Terra and Aqua MODIS data. IEEE Trans. Geosci. Remote Sens., doi: 10.1109/TGRS.2019.2926620. **ED4 CLOUD MASK**

Minnis, P., S. Sun-Mack, Y. Chen, C. R. Yost, W. L. Smith, Jr., F.-L. Chang, P. W. Heck, R. F. Arduini, Q. Z. Trepte, K. Ayers, K. Bedka, S. Bedka, R. R. Brown, D. R. Doelling, A. Gopalan, E. Heckert, G. Hong, Z. Jin, R. Palikonda, R. Smith, B. Scarino, D. A. Spangenberg, P. Yang, Y. Xie, and Y. Yi, 2019: CERES MODIS cloud product retrievals for Edition 4, Part I: Algorithm changes. IEEE Trans. Geosci. Remote Sens., **ED4 ALGORITHM – under review**.

Yost, C., P. Minnis, S. Sun-Mack, Y. Chen, and W. L. Smith, Jr., 2019: CERES MODIS cloud product retrievals for Edition 4, Part II: Comparisons to CloudSat and CALIPSO. IEEE Trans. Geosci. Remote Sens., **ED4 VALIDATION - - under review**.

Other Edition-4 Related Papers

Su, W., P. Minnis, L. Liang, D. P. Duda, K. Khlopenkov, M. M. Thiemann, Y. Yu, A. Smith, S. Lorentz, D. Feldman, and F. P. J. Valero, 2020: Determining the daytime Earth radiative flux from National Institute of Standards and Technology Advanced Radiometer (NISTAR) measurements. Atmos. Meas. Tech., 13, 429-443.

Painemal, D., Chang, F.-L., Ferrare, R., Burton, S., Li, Z., Smith Jr., W. L., Minnis, P., Feng, Y., and Clayton, M.: Reducing uncertainties in satellite estimates of aerosol-cloud interactions over the subtropical ocean by integrating vertically resolved aerosol observations, Atmos. Chem. Phys. Discuss., in review, 2019.

Painemal, D., Spangenberg, D., Smith Jr., W. L., Cairns, B., Moore, R., Minnis, P.: Evaluation of satellite retrievals of liquid clouds from GOES-13 Imager and MODIS over the midlatitude North Atlantic during NAAMES campaign , JGR, submitted, 2020.

In Preparation

Smith, W. L., D. Doelling, P.Minnis, D. Painemal, B. Scarino, S. Sun-Mack, K. Bedka: Assessment of CERES and SatCORPS Cloud Climate Data Records and Factors that Influence Temporal Continuity and Cross-Platform Consistency, in preparation for MDPI Remote Sensing special issue.

Minnis P. and coauthors: CERES VIIRS Edition-1 cloud retrievals, in preparation.

Clouds - Processing Status

CERES-MODIS Edition 4 Status	*Aqua: Jul 2002 – Mar 2020 (~17.5 y)* *Terra: Feb 2000 – Mar 2020 (~20 y)* ***MODIS Calibration Strategy:*** • ***MODIS Collection 5 thru Feb 2016,*** • ***MODIS Collection 6.1 March 2016 - present*** • ***C6.1 radiances are scaled to C5 for consistency over entire record*** • ***Terra-MODIS normalized to Aqua-MODIS (Sun-Mack, et al. 2018)***
CERES-VIIRS Ed 1 Status	*SNPP: Jan 2012 – Mar 2020 (~8 y)* ***VIIRS Calibration Strategy:*** • ***Use forward processing calibrations, not scaled to MODIS*** • ***Inconsistencies/discontinuity in this record*** *NOAA-20: Jan 2018 – Jan 2020 (~2 y)* ***VIIRS Calibration Strategy:*** ***Scaled to Aqua-C5 using Jul 2019 data***

S-NPP Edition 2 and NOAA-20 Edition 1 VIIRS Cloud Properties

- The CERES Terra & Aqua Edition 4.1 processing uses MODIS Edition 4 clouds.
- Since Terra and Aqua are nearing end of life and begin drifting in 2021 and 2022, the CERES CDR will transition from Aqua to NOAA-20 or S-NPP.
- A major goal for the next CERES edition (Ed5) will be to provide improved consistency and a more seamless transition in cloud properties across satellite platforms (MODIS to VIIRS, and improved GEO).
- While Edition-5 work is in progress, cloud properties from earlier editions will be used to implement and evaluate the use of VIIRS in CERES (FM-5, FM-6) data processing.
- Two new editions: S-NPP Edition 2 and NOAA-20 Edition 1 apply new calibrations to normalize VIIRS and MODIS radiances but employ the S-NPP Ed1 algorithm (different from MODIS Ed4 algorithm). These Editions are not designed for continuity with MODIS
- Continuity version of VIIRS and MODIS algorithms deferred to CERES Ed5

S-NPP Edition 2 Clouds Status

What is S-NPP Edition 2

- Places VIIRS on same radiometric scale as Aqua MODIS.
  - Scalings to be developed at beginning of S-NPP record (May 2012)
- Uses collection 2 (C2) level 1b radiances (NPP Ed1 used C1)
- Uses NASA Deep Blue aerosol product (NPP Ed1 used NOAA aerosols)
- Cloud algorithm identical to Ed1
  - Can expect some Ed1/Ed2 cloud property differences due to different calibrations

Ed2 code is delivered and ready to process, but

- awaiting VIIRS C2 level 1b delivery from GSFC
- Need C2 for consistent radiances over entire record
- C2 delayed due to co-registration problem
- fix in place and in testing

NOAA-20 Edition 1 Clouds Status

- 25-months of NOAA-20 VIIRS have been processed: Jan 2018 – Feb 2020
- NOAA-20 Edition 1 cloud algorithm identical to S-NPP Edition 1 & 2 algorithms
- July 2019 data were used to scale NOAA-20 VIIRS to Aqua-C5

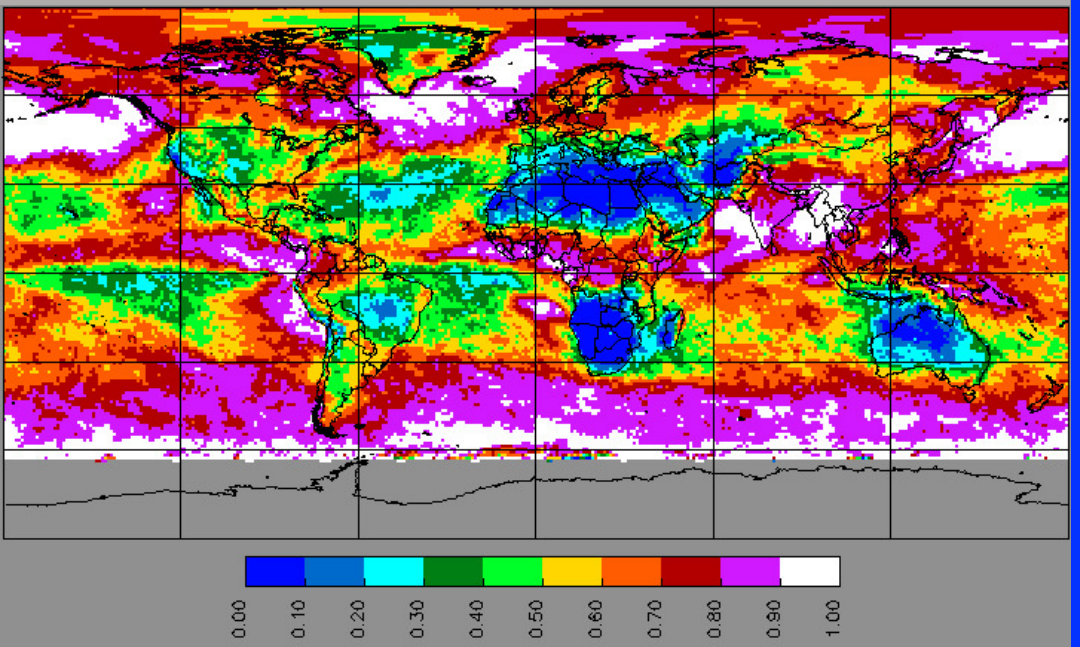
The same calibration procedure was also applied to S-NPP VIIRS (C1 radiances) to test our ability to derive consistent cloud properties from different satellites (albeit same instrument) using the same cloud algorithm. *Eventually we will do this with MODIS and VIIRS once the algorithms are unified.*

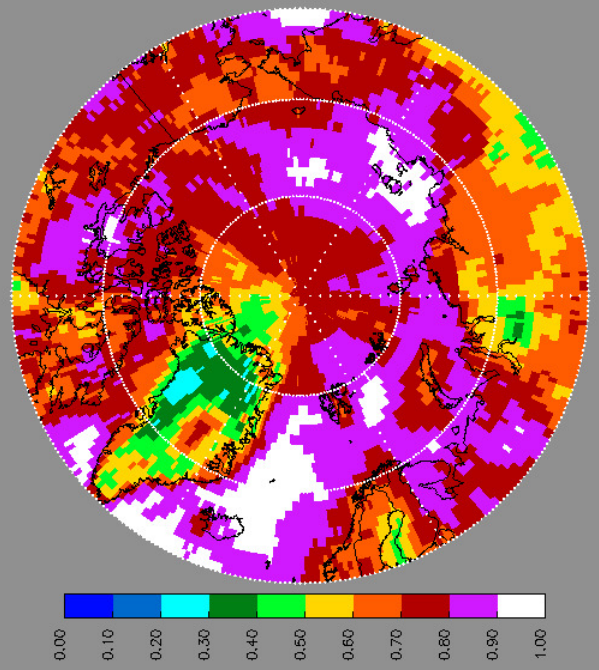
NOAA-20 Ed-1 Cloud Fraction

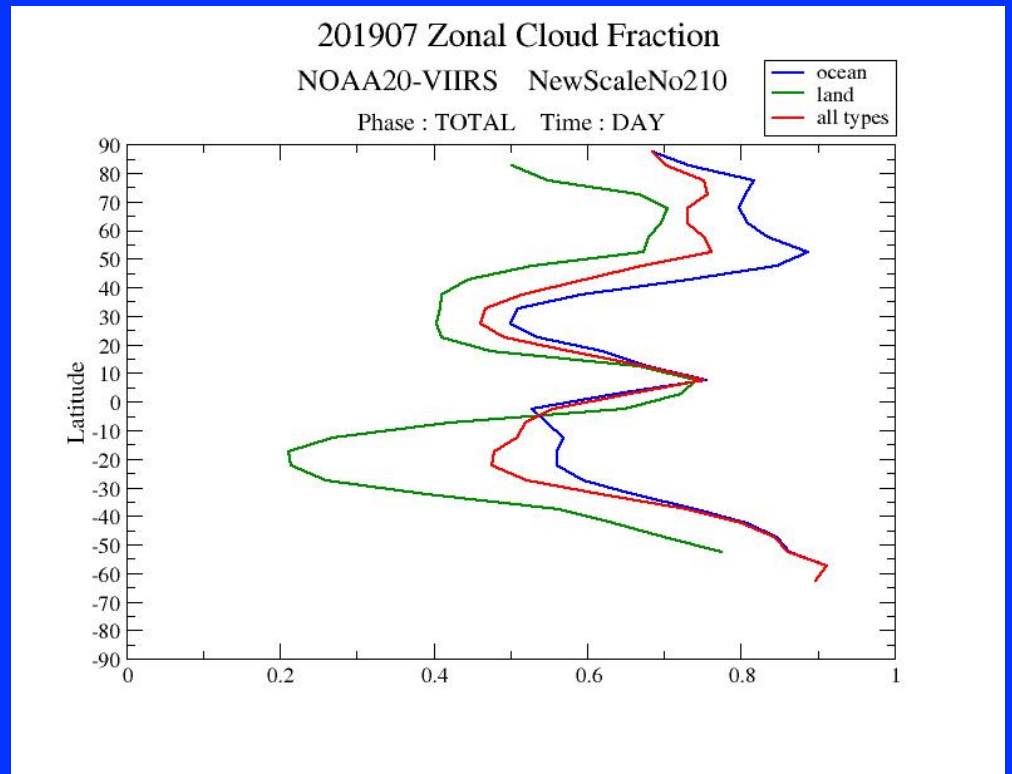
July 2019, Daytime

Consistent cloud properties are derived from two different satellites in the same orbit with the same imager - when radiometrically scaled and using same cloud algorithm

Total Cloud Fraction (Daytime)
NOAA-20 VIIRS July 2019



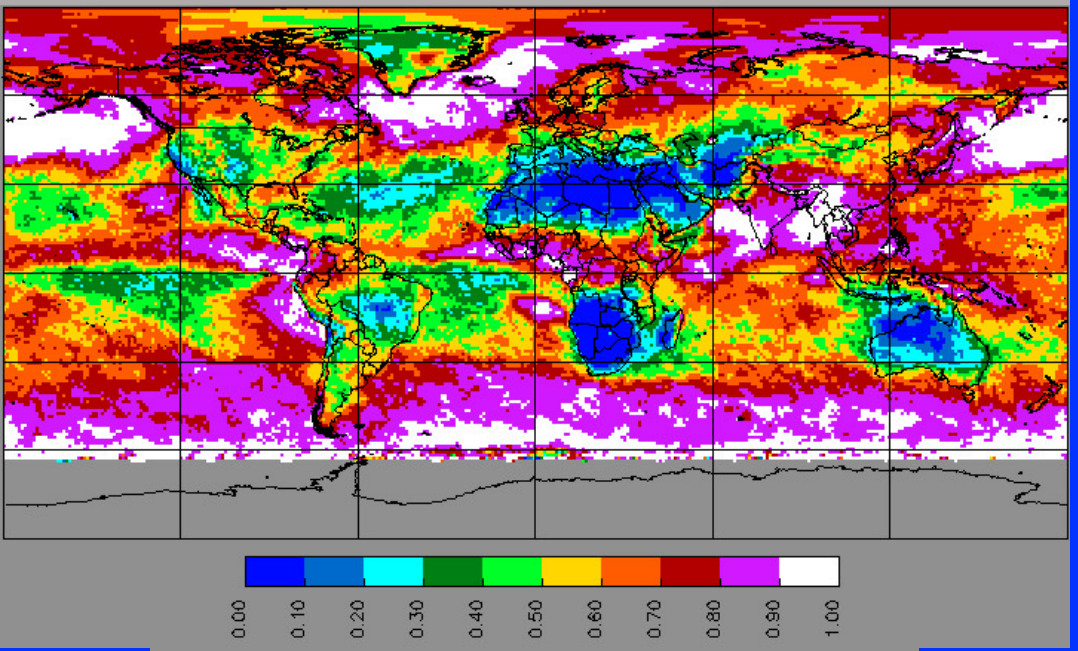


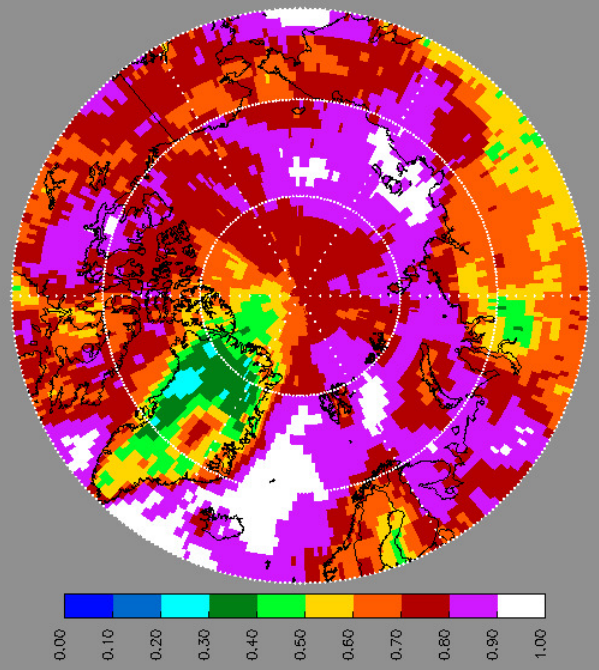


S-NPP Cloud Fraction (w/July scalings)

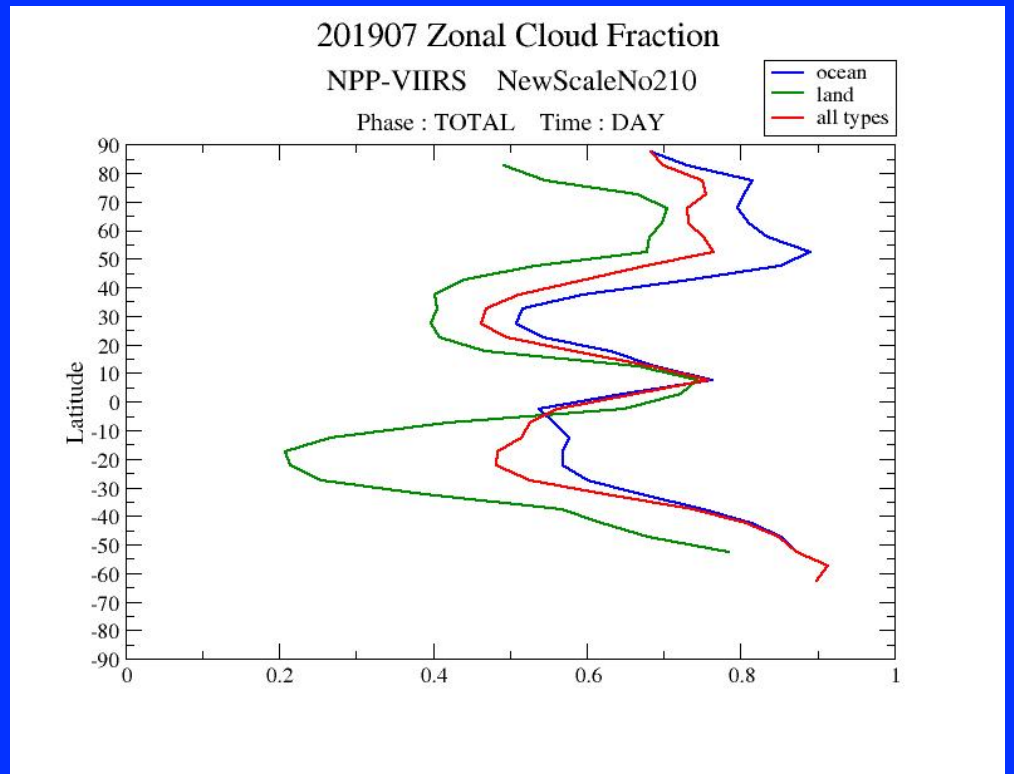
July 2019, Daytime

Total Cloud Fraction (Daytime)
S-NPP VIIRS July 2019





Consistent cloud properties are derived from two different satellites in the same orbit with the same imager - when radiometrically scaled and using same cloud algorithm

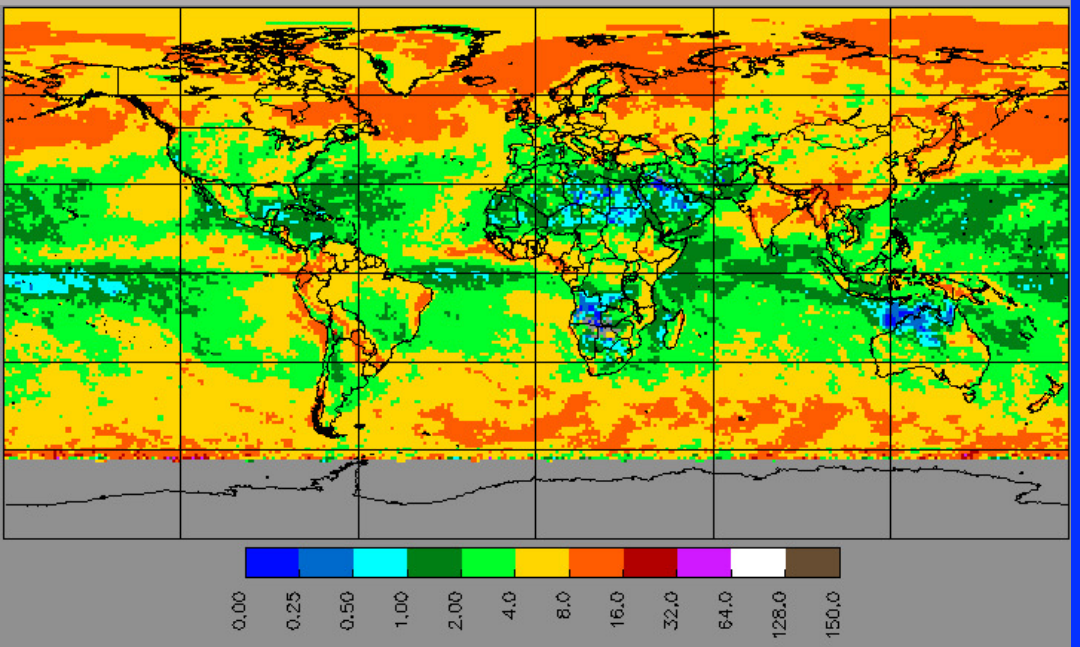


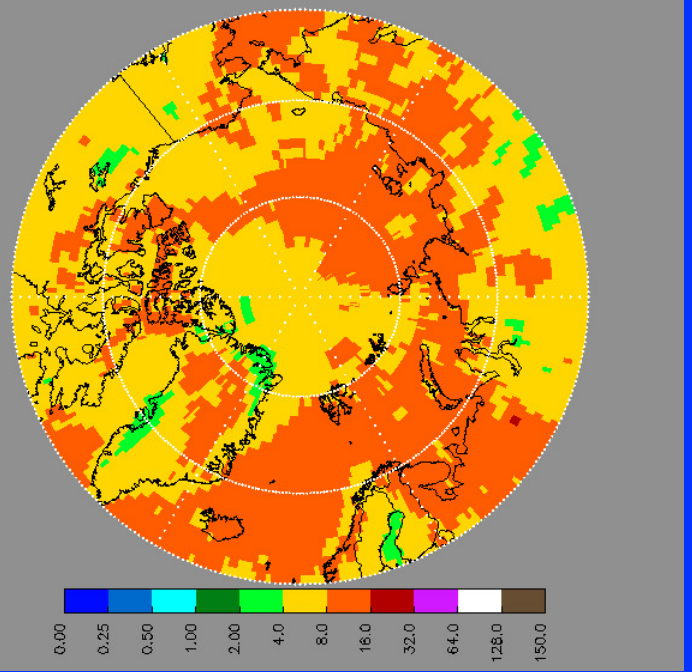
NOAA-20 Ed1 Cloud Optical Depth

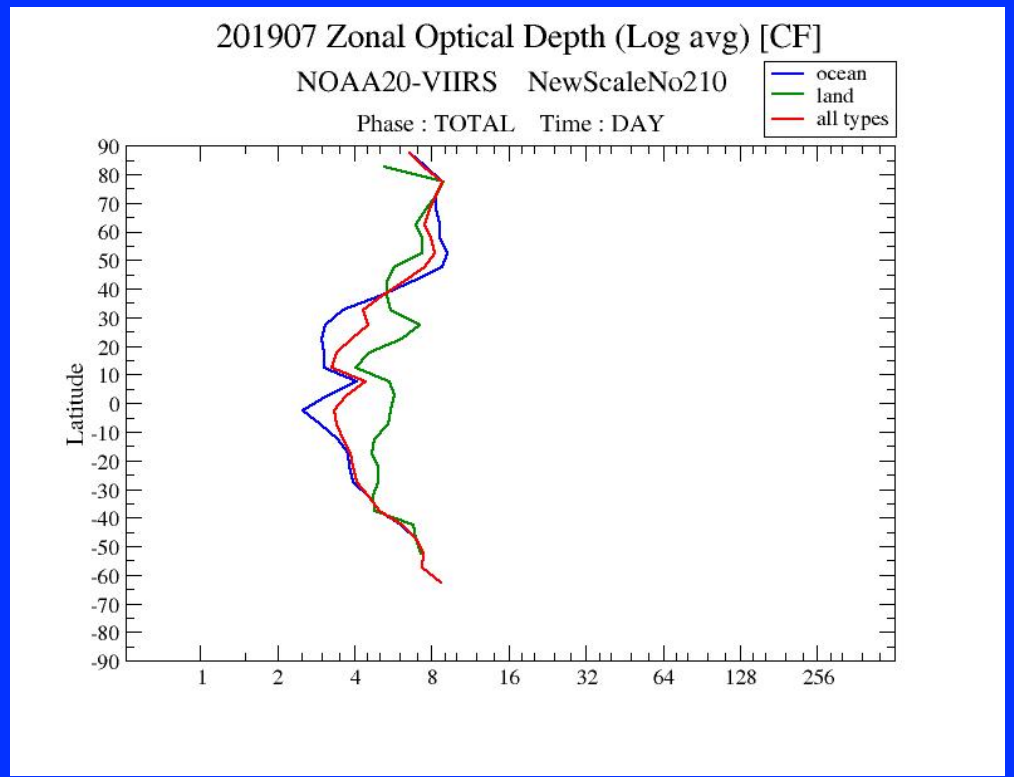
July 2019, Daytime

Consistent cloud properties are derived from two different satellites in the same orbit with the same imager - when radiometrically scaled and using same cloud algorithm

Total Cloud Optical Depth (Daytime)
NOAA-20 VIIRS July 2019



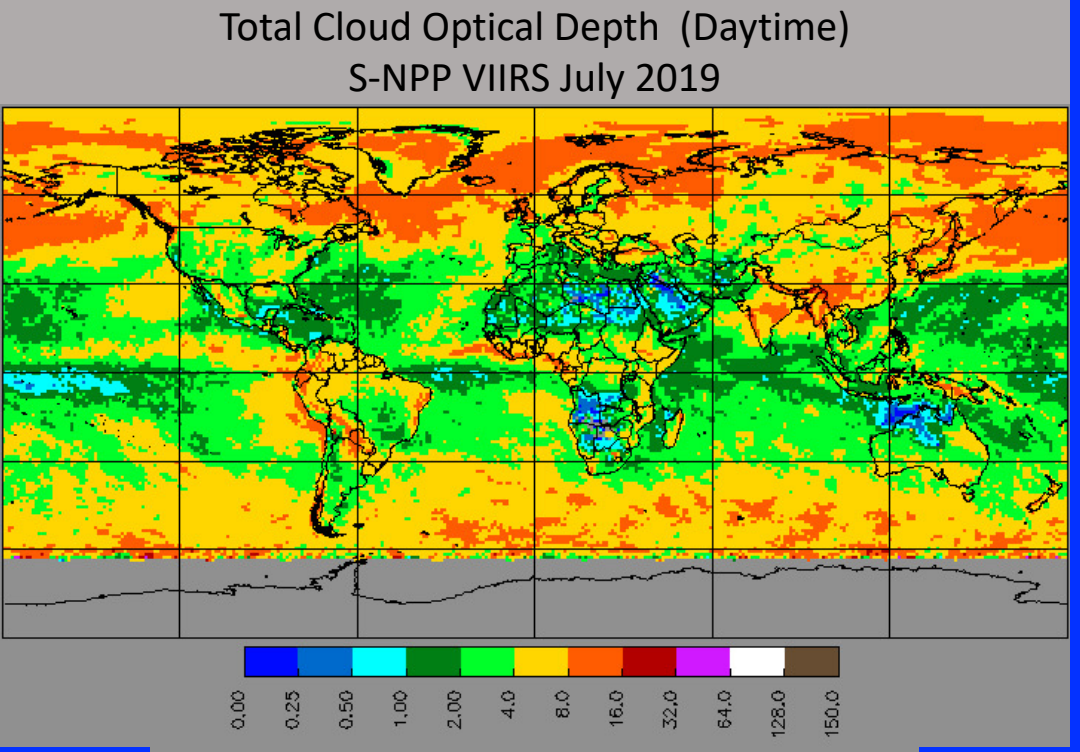


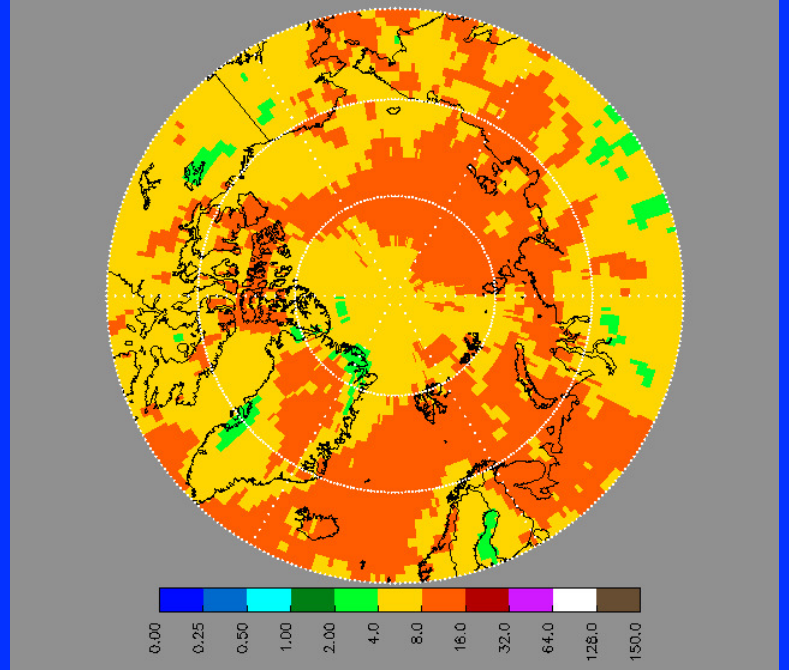


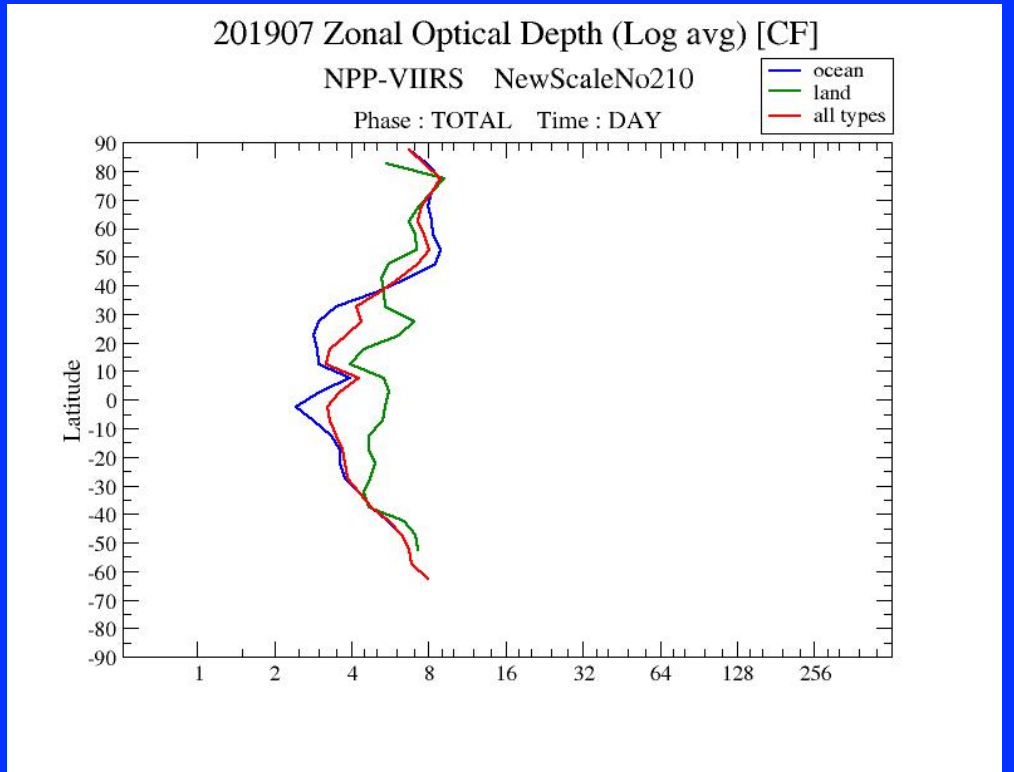
S-NPP Cloud Optical Depth

July 2019, Daytime

Consistent cloud properties are derived from two different satellites in the same orbit with the same imager - when radiometrically scaled and using same cloud algorithm



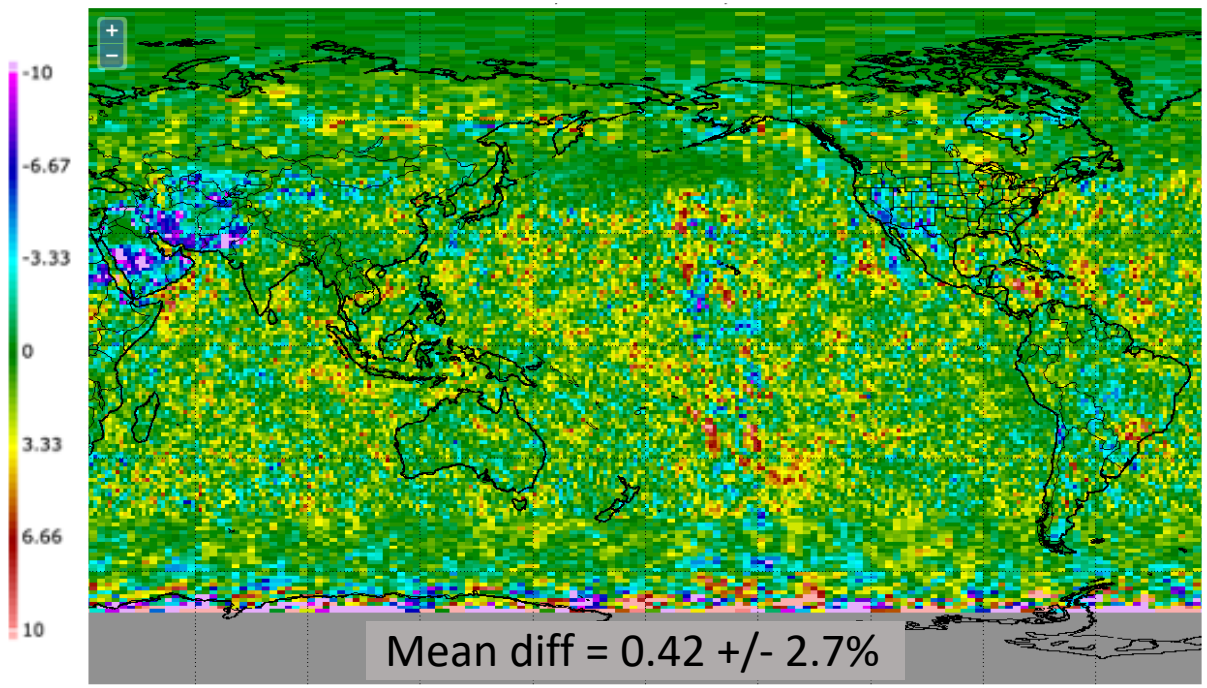




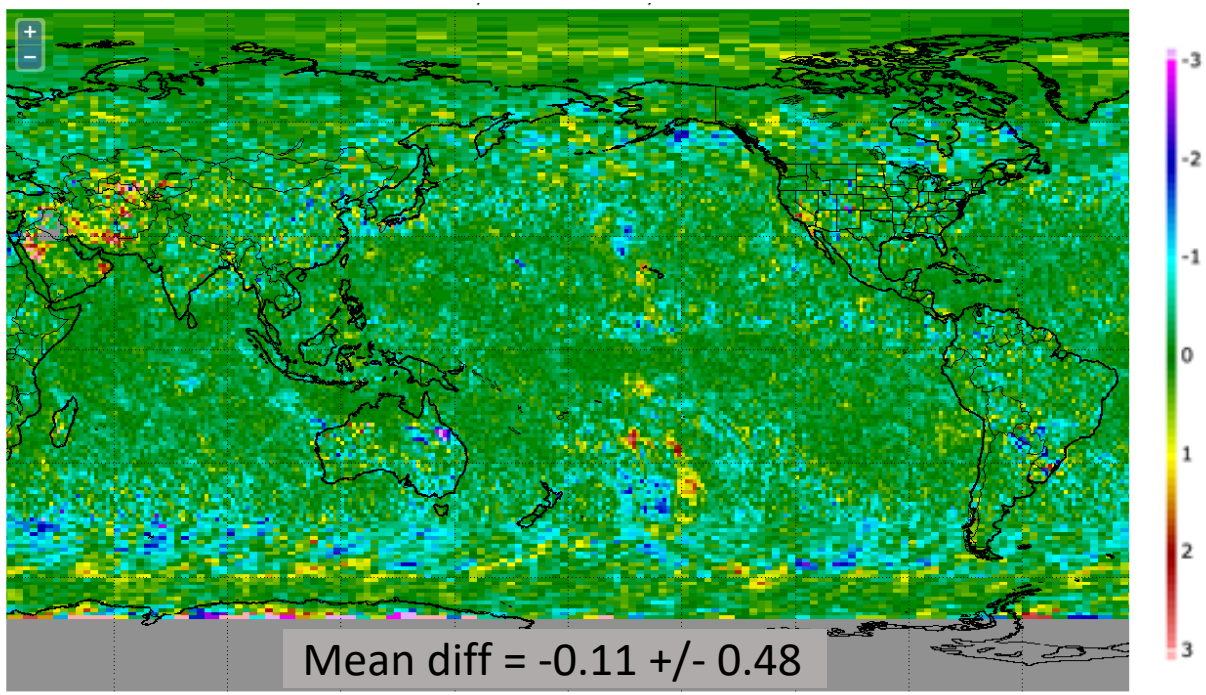
Comparison NPP – N20 clouds (SSF1deg)

July 2019

NPP-N20 daytime cloud fraction (%)



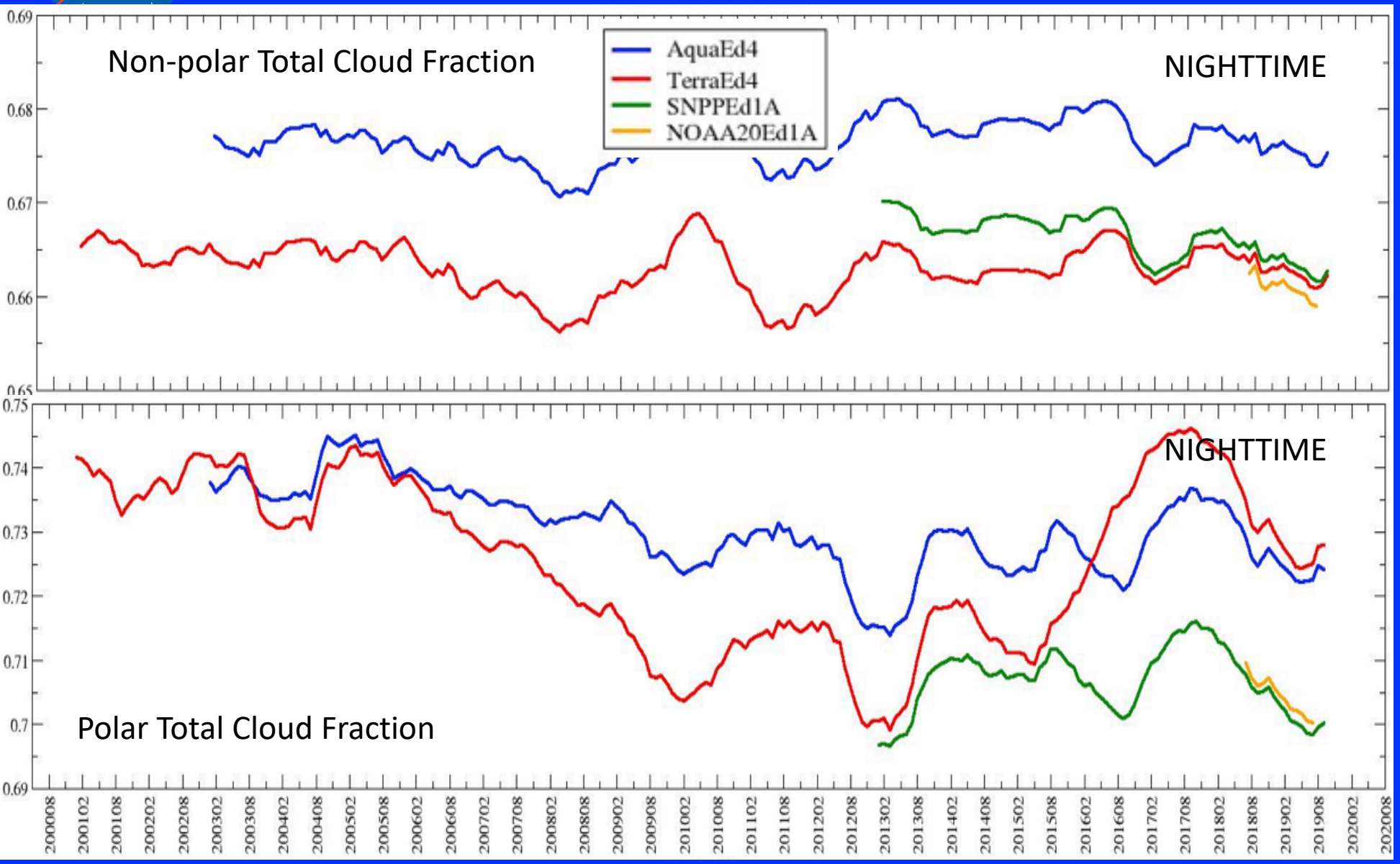
NPP-N20 daytime optical depth



- Monthly mean differences somewhat noisy due orbit differences (ECT 45 minutes apart; time and vza differences)
- On average, N20 CF 0.42% lower than NPP; Tau ~ 0.11 higher
- Scaling approach seems to work well

Cloud Fraction Time Series (Night)

12-month running means



All satellites tracking well

N20 agrees well with SNPP (Ed1) despite no cross-calibration

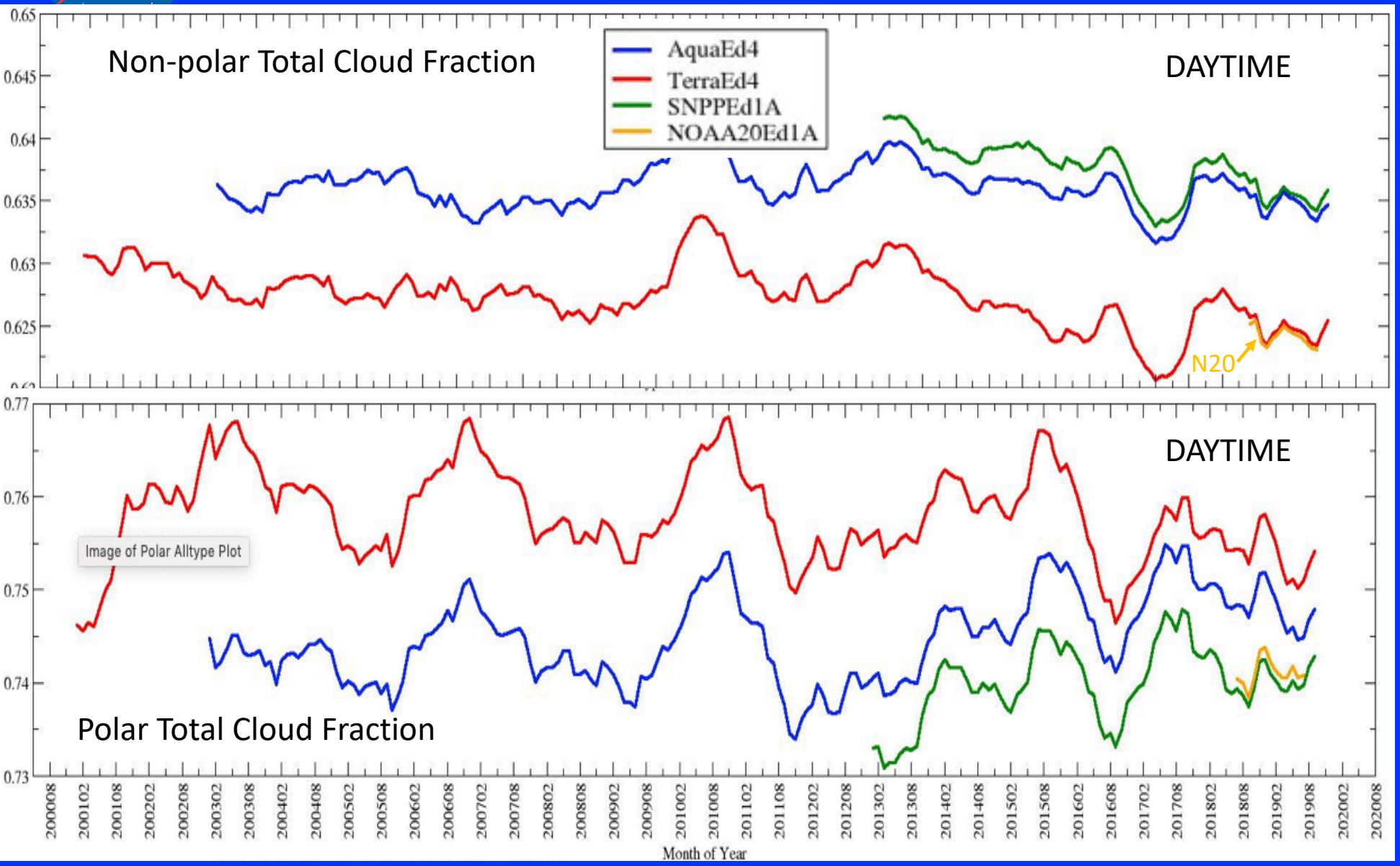
NPP and N20 have fewer clouds than Aqua (-1% NP, -2.5% Polar)

Polar diffs mostly due to different algorithms (no VIIRS 6.7, 13 µm channel) and 3.7 µm calibration issue at cold temperatures

Terra time series much different than others due to unmitigated instrument degradation prior to 2016 and a 2016 correction

Cloud Fraction Time Series (Day)

12-month running means



All satellites tracking well

SNPP-Ed1 very close to Aqua (<0.5%) despite no cross-calibration. However, VIIRS cloud mask tuned to improve agreement.

N20 1% lower (non-polar) than Aqua and NPP Ed1, and not yet understood.

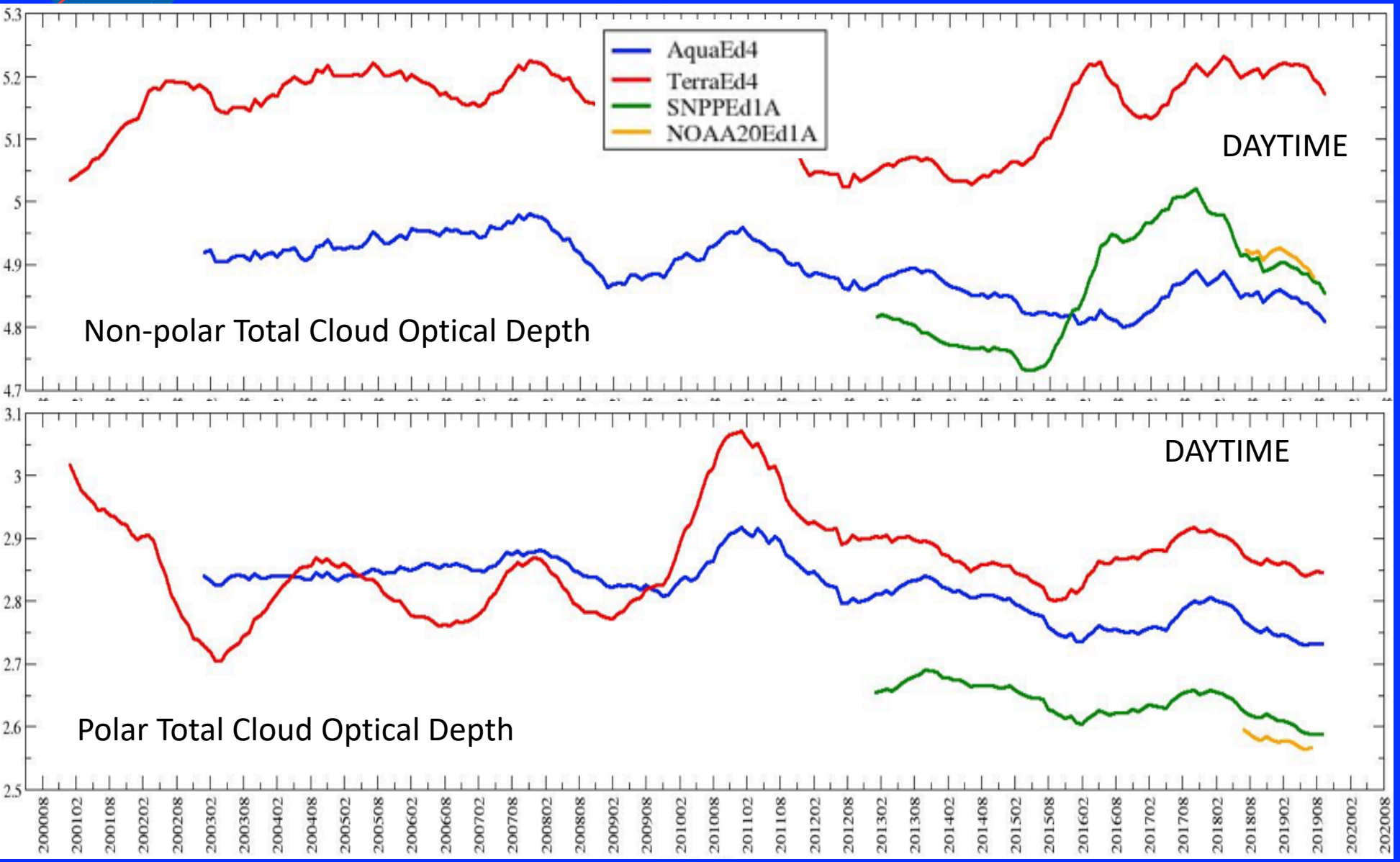
N20 agrees well with SNPP in polar regions.

Terra diffs (1%) mostly due to diurnal cycle.

Terra trends different due to Terra calibration issues after 2016.

Cloud Optical Depth Time Series (Day)

12-month running means



Terra and SNPP not tracking Aqua well due to calibration issues

Artificial jump in SNPP COD due to 2016 vis channel discontinuity

N20 and SNPP-Ed1 in close agreement with each other despite no radiometric scaling.

Status Summary - and words of caution

- NOAA-20 cloud properties are looking good and we are making good progress on the radiometric scaling procedures
- MODIS & VIIRS cloud properties have some inconsistencies
  - algorithms not identical, use different channels
  - VIIRS Ed1 and MODIS Ed4 not on same radiometric scale
  - VIIRS Ed1 time series has calibration discontinuities
- Ed4 MODIS cloud properties superior to earlier versions (see references slide 3)
  - earlier versions should not be used!!
- Terra-MODIS Ed4 has artificial trends due to unmitigated calibration problems
  - uncertain prior to 2002 (beginning of Aqua normalization),
  - instrument degradation from ~2006-2016, 2016 discontinuity due to major instrument anomaly
- Aqua-MODIS Ed4 cloud properties are most stable timeseries
  - most reliable dataset for tracking cloud changes and trends
- Cloud properties should be assessed separately for day/night, over snow-ice
  - uncertainties larger at night and over snow/ice
  - fill values used for some optically thick cloud properties (tau, R_e) at night
  - Combining day & night, snow-ice & snow-ice free can lead to artificial changes/trends

CERES Edition 5 Plans

What is Edition 5 for the Cloud Subsystem

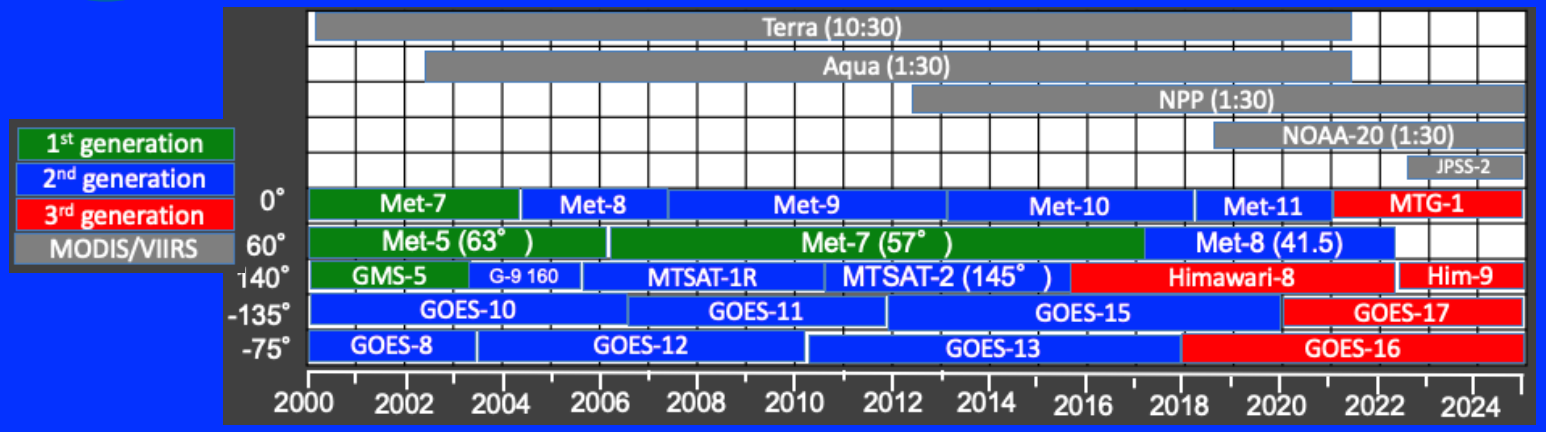
- Next edition MODIS Cloud properties designed for continuity with VIIRS (MODIS Ed5)
- Next edition VIIRS Cloud properties designed for continuity with MODIS (internally VIIRS Ed3)
- Next Edition GEO cloud properties designed for better consistency among satellites (Ed5 GEO)

Key Elements Planned for Edition 5

- All LEO and GEO imagers placed on same radiometric scale using Aqua MODIS Collection as the reference
- Will apply forward models and cloud retrieval algorithms to MODIS and VIIRS that are as consistent as possible (i.e. use consistent inputs, similar spectral bands and retrieval methods)
- A new GEO continuity product (2-3 channel nighttime, 3 channel daytime)
- Many algorithm revisions & bug fixes

Challenges for Consistent GEO Clouds in CERES

~20 different satellites



1st generation satellite

Satellite	Channels (μm)
MET-5	0.6, 11
MET-7	0.6, 11
GMS-5	0.6, 11

3rd generation satellite

Satellite	Available Channels (μm)
GOES-16	0.6, 3.9, 6.7,11, 12, 1.6, 8.7, 13.3
GOES-17	0.6, 3.9, 6.7,11, 12, 1.6, 8.7, 13.3
HIMAWARI-8	0.6, 3.9, 6.7,11, 12, 1.6, 8.7, 13.3

- CERES GEO approach in Ed4 was to utilize as much available spectral information as possible to improve consistency with MODIS
- Different algorithms applied to different satellites led to discontinuities
- Satellite specific SRF's not always accounted for in Ed4 GEO retrievals
- 0.6, 3.9, 6.7, 11 μm are common denominator across most of record

2nd generation satellite

Satellite	Available Channels (μm)
GOES-8	0.6, 3.9, 6.7, 11, 12
GOES-9	0.6, 3.9, 6.7, 11, 12
GOES-10	0.6, 3.9, 6.7, 11, 12
GOES-11	0.6, 3.9, 6.7, 11, 12
MTSAT-1R	0.6, 3.7, 6.7, 11, 12
MTSAT-2R	0.6, 3.7, 6.7, 11, 12
GOES-12	0.6, 3.7, 6.7, 11, 13.3
GOES-13	0.6, 3.7, 6.7, 11, 13.3
GOES-14	0.6, 3.7, 6.7, 11, 13.3
GOES-15	0.6, 3.7, 6.7, 11, 13.3
MET-8	0.6, 3.9, 6.7,11, 12, 1.6, 8.7, 13.3
MET-9	0.6, 3.9, 6.7,11, 12, 1.6, 8.7, 13.3
MET-10	0.6, 3.9, 6.7,11, 12, 1.6, 8.7, 13.3
MET-11	0.6, 3.9, 6.7,11, 12, 1.6, 8.7, 13.3

CERES Edition 5 Status

New Edition 5 GEO processing framework under construction

- Applies 3-channel methods during daytime (0.65, 3.9, 10.8 µm) and nighttime (3.9 , 6.7, 10.8 µm)
- Incorporates two-habit ice crystal model
- Incorporates satellite-specific spectral response functions for 3.9 and 10.8 µm
- Incorporates satellite specific emittance models
- Incorporates optional machine learning method for optically thick cloud properties at night to improve day/night consistency
- Implements numerous bug fixes and other advances developed for LEO, clear sky improvements, etc.

New Edition 5 LEO (MODIS & VIIRS) processing framework under construction

- Incorporates new clear sky maps and models for all channels
- Employs VIIRS Ed1 cloud mask on common channels for both instruments
- Incorporates two-habit ice crystal model and unifies water droplet models
- Unifies cloud retrieval methods utilizing common channels from both instruments
- Incorporates 1.6 µm retrieval for cloud optical depths over snow/ice
- Implements numerous bug fixes
- Designed for rapid implementation and testing of new/improved algorithms (e.g. empirical methods for cloud top height, cloud thickness, cloud water path, multi-layer cloud information)

CERES Edition 5 Status

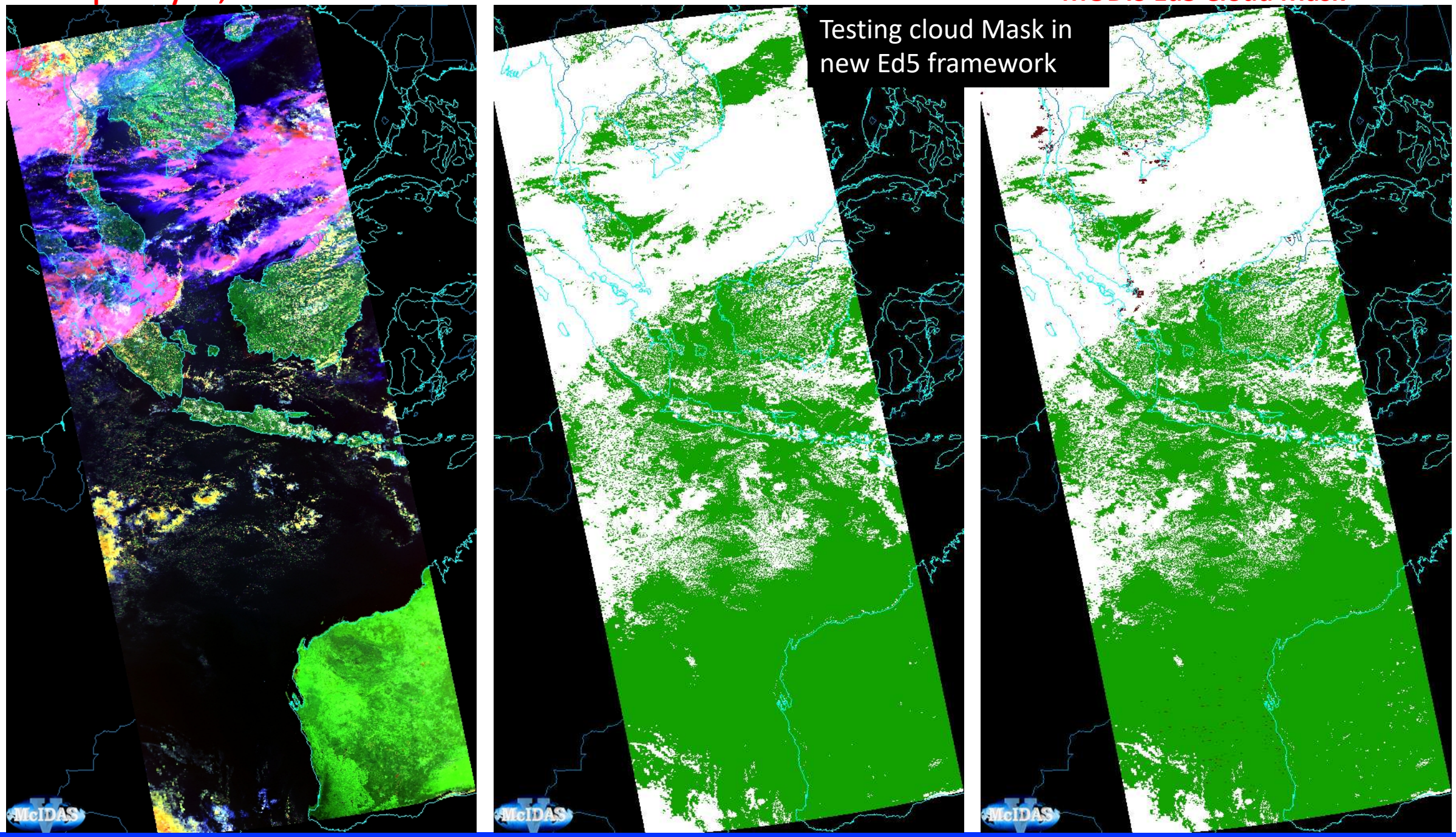
All Ed5 work in various stages of completion

- Some reported at previous meetings and later this week
- Most of the critical work with the cloud models & retrieval algorithms is completed
- The cloud mask is currently be tested in the LEO framework; retrieval tests start soon
- The 3-channel GEO methods are implemented and now being tested (mask and retrievals)
- Clear sky methods still need work, especially for GEO with less spectral information available
- Lots of loose ends that need completion (take from conference presentation to more rigorous testing and full implementation
- Expect significant updates next two science team meetings

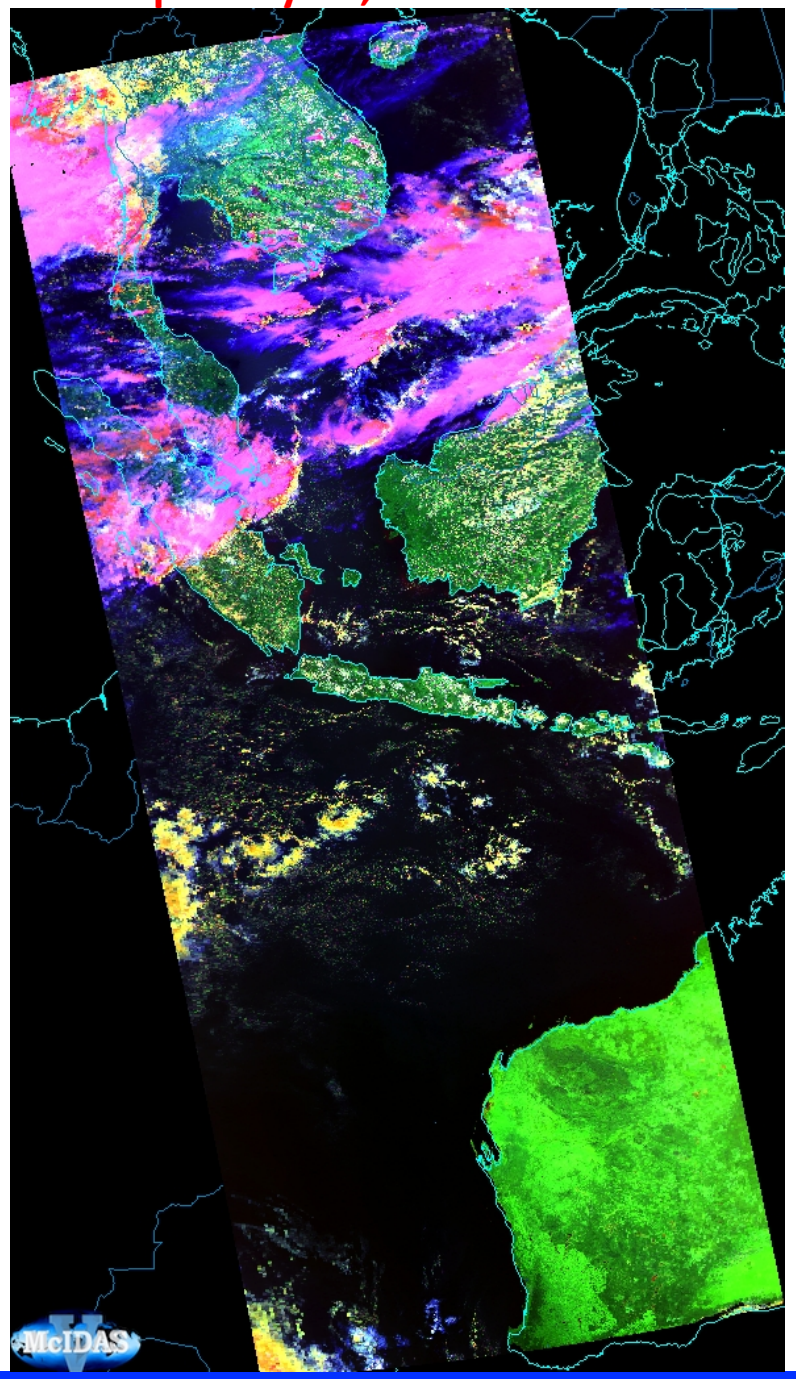
Aqua July 15, 2019 0615-0625

MODIS Ed4 Cloud Mask

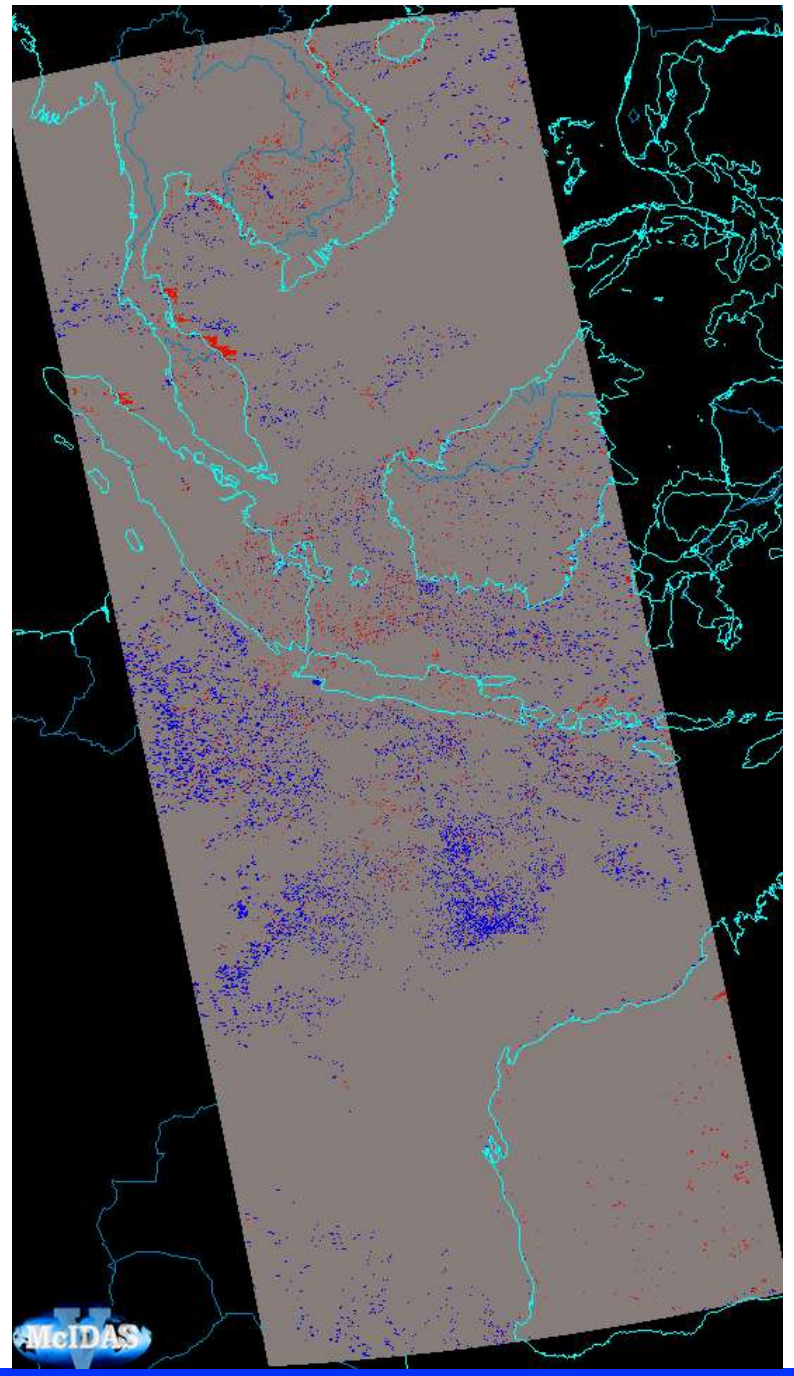
MODIS Ed5 Cloud Mask



Aqua July 15, 2019 0615-0625



Ed5 mask - Ed4 Mask



First tests of the Edition 5 cloud mask from the Edition 5 framework

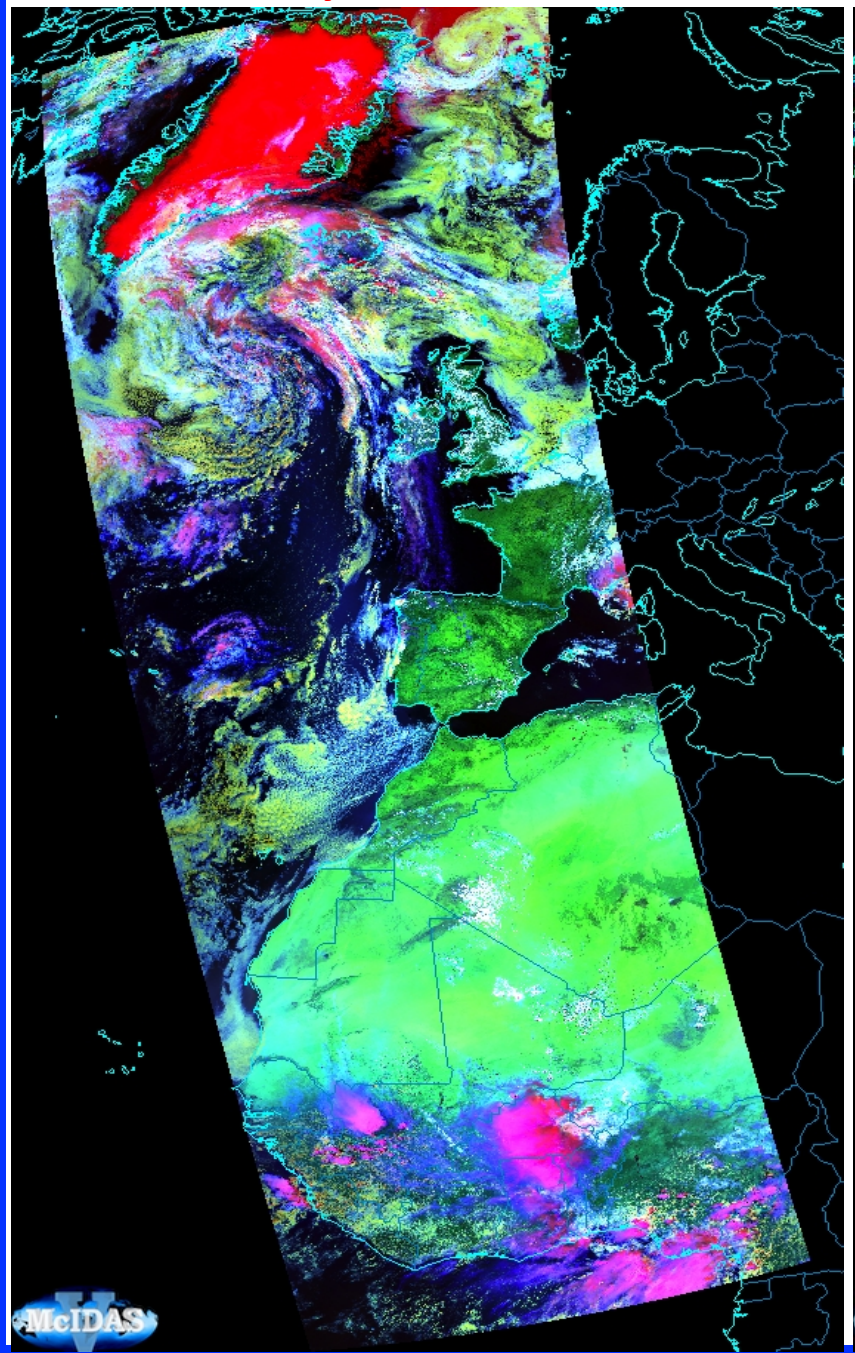
- Updated version of VIIRS Ed1 cloud mask applied to MODIS data
- Eliminates Ed4 use of 6.7 and 13 µm channel and incorporates new clear sky radiance maps among other things
- Some MODIS Ed4/Ed5 differences to be expected

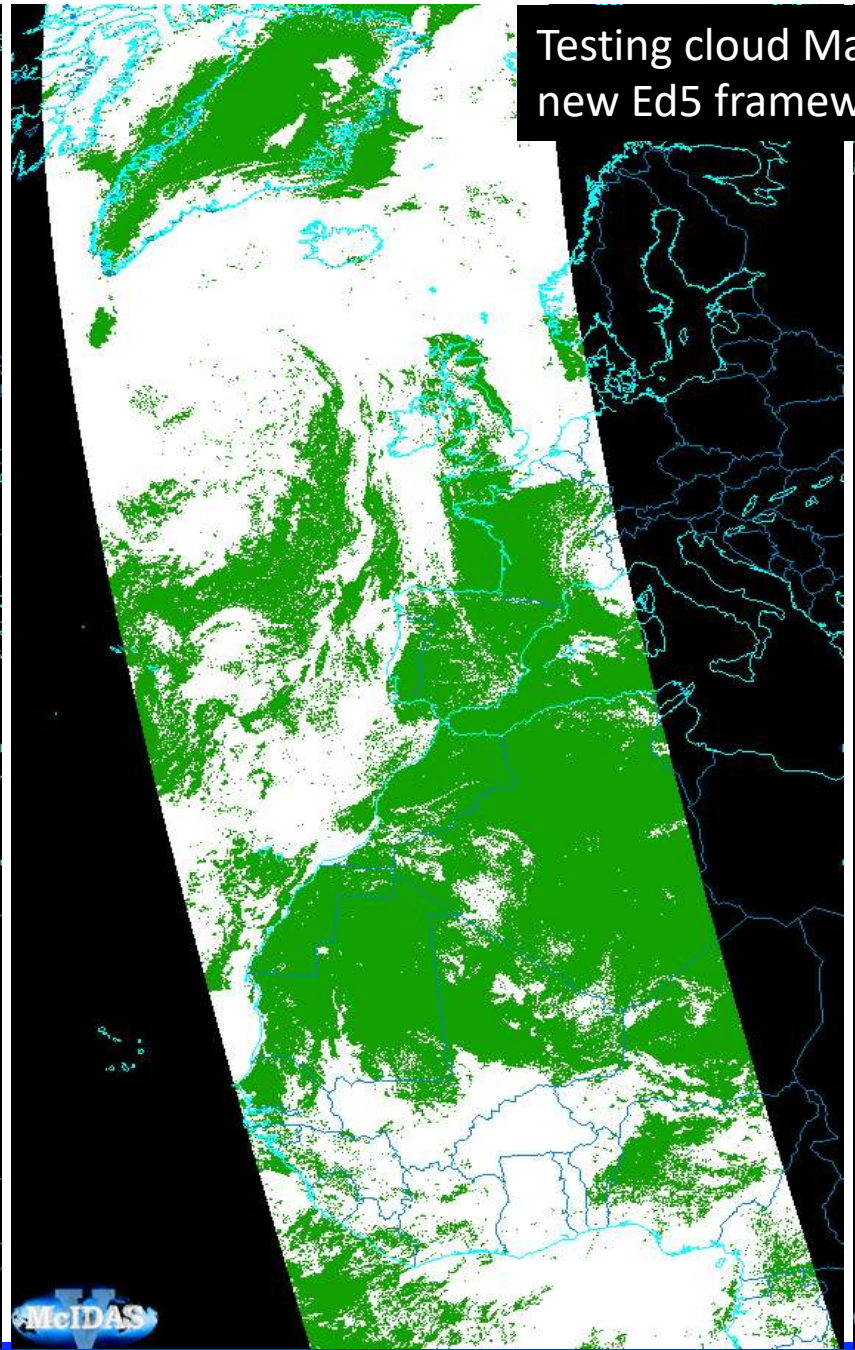
Mask Difference

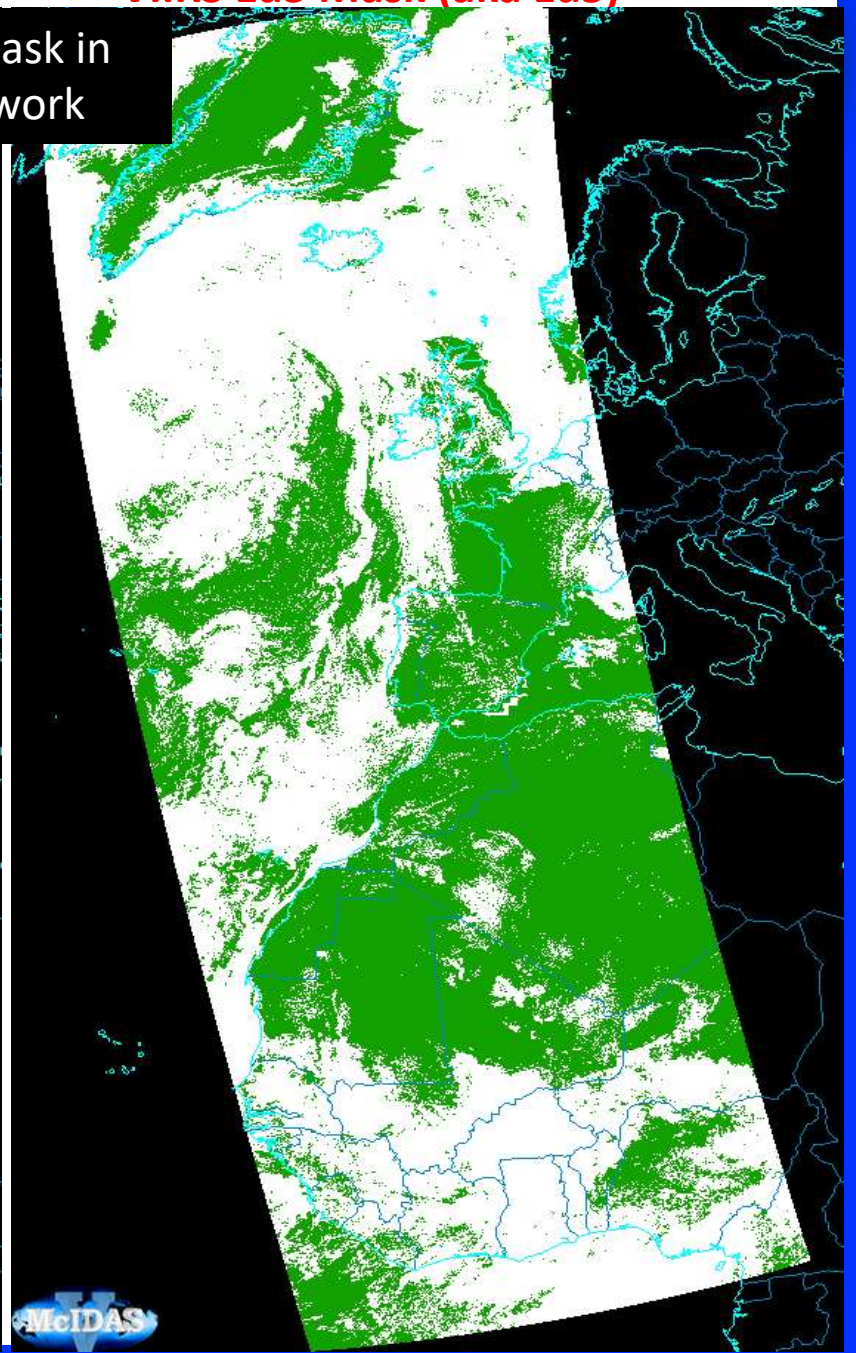
NPP VIIRS July 15, 2019, UTC 1324-1342

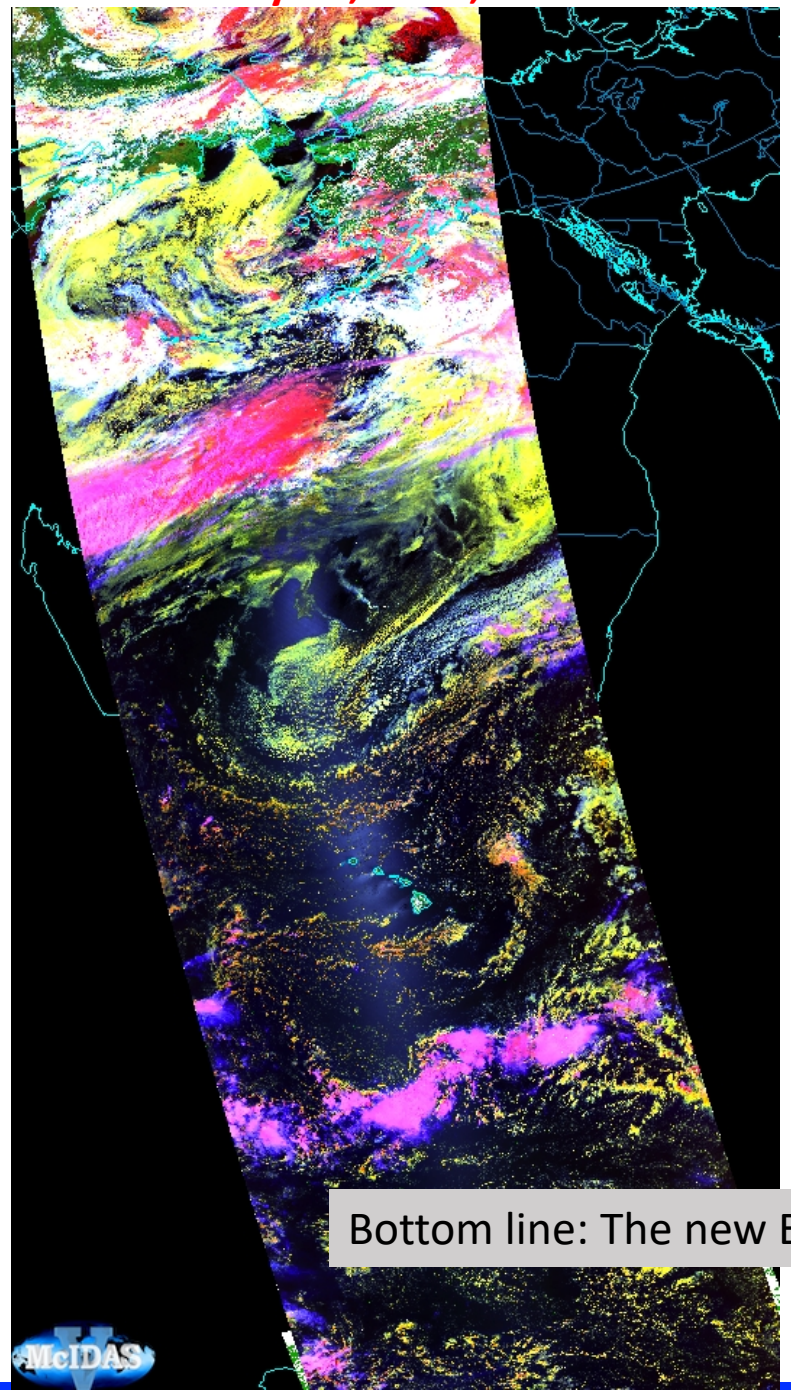
VIIRS Ed1 Mask

VIIRS Ed3 Mask (aka Ed5)

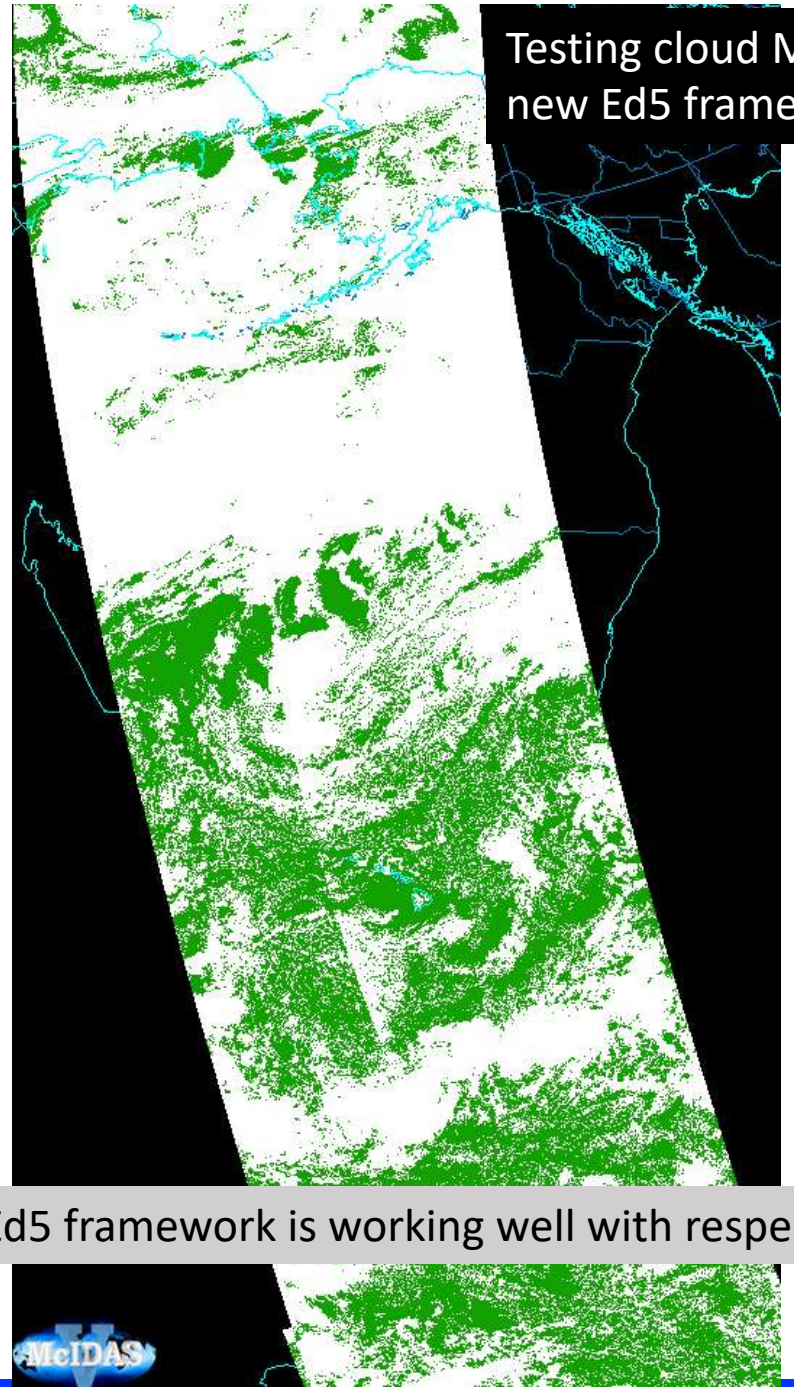




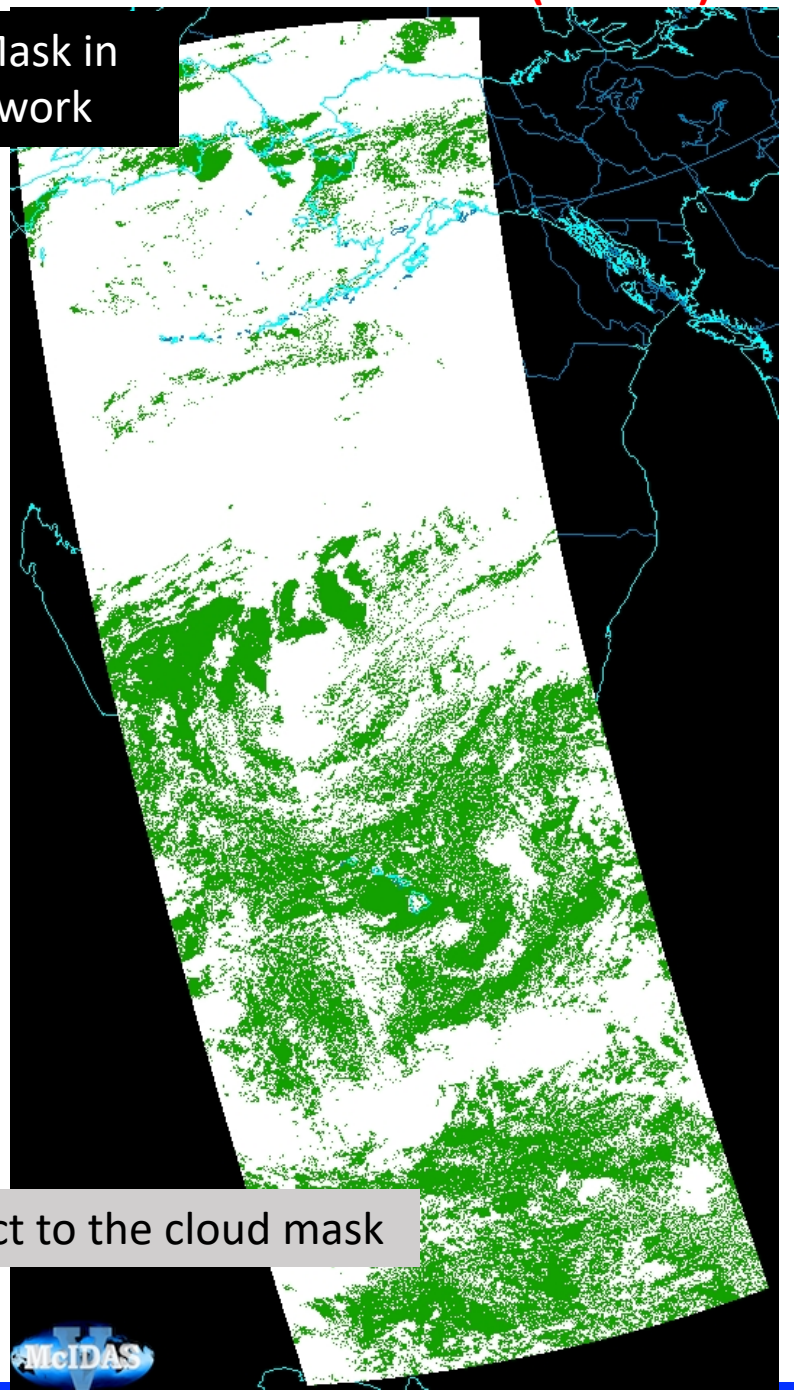




NPP VIIRS July 15, 2019, UTC 2330-2348



VIIRS Ed1 Mask

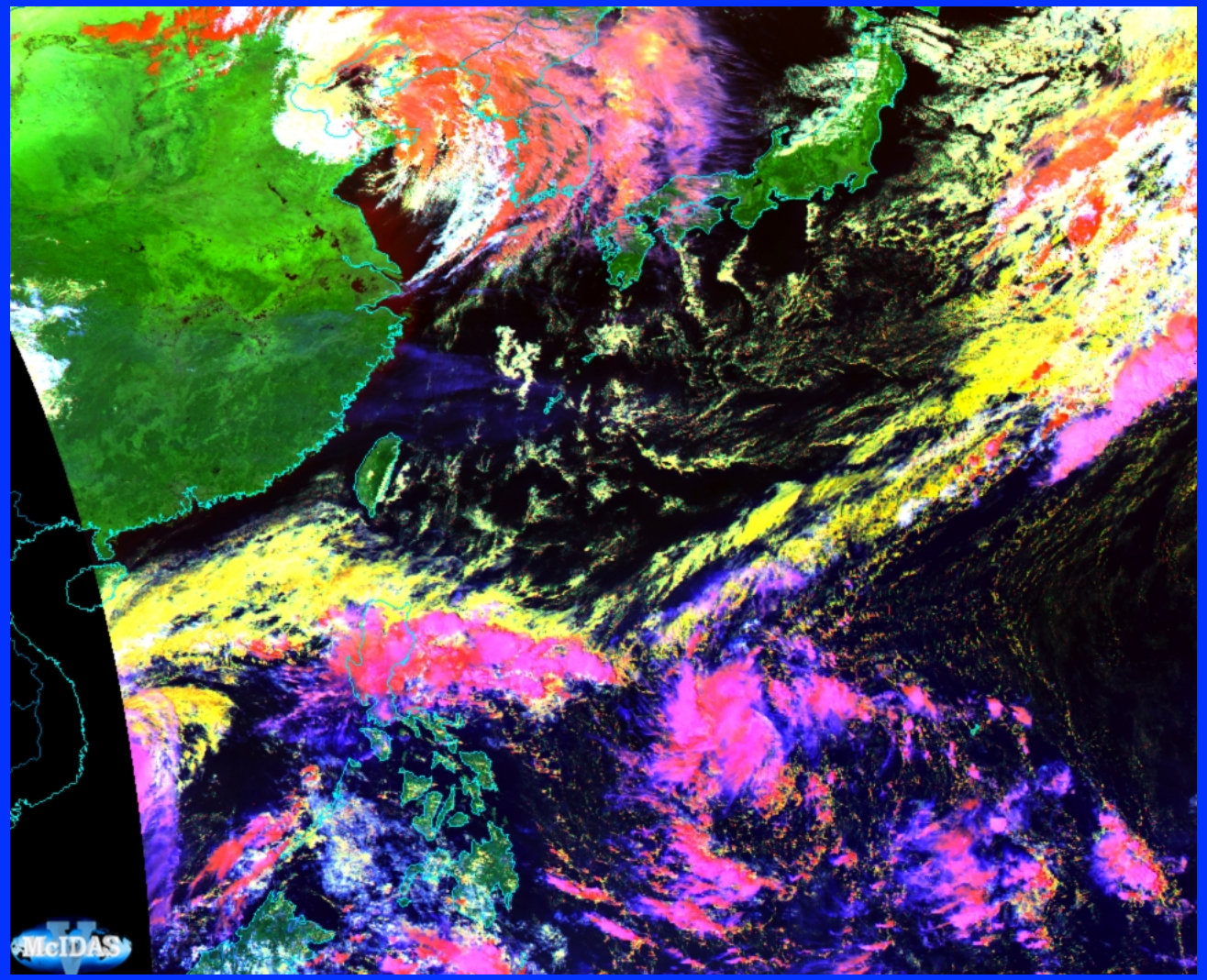


VIIRS Ed3 Mask (aka Ed5)

Testing cloud Mask in new Ed5 framework

Bottom line: The new Ed5 framework is working well with respect to the cloud mask

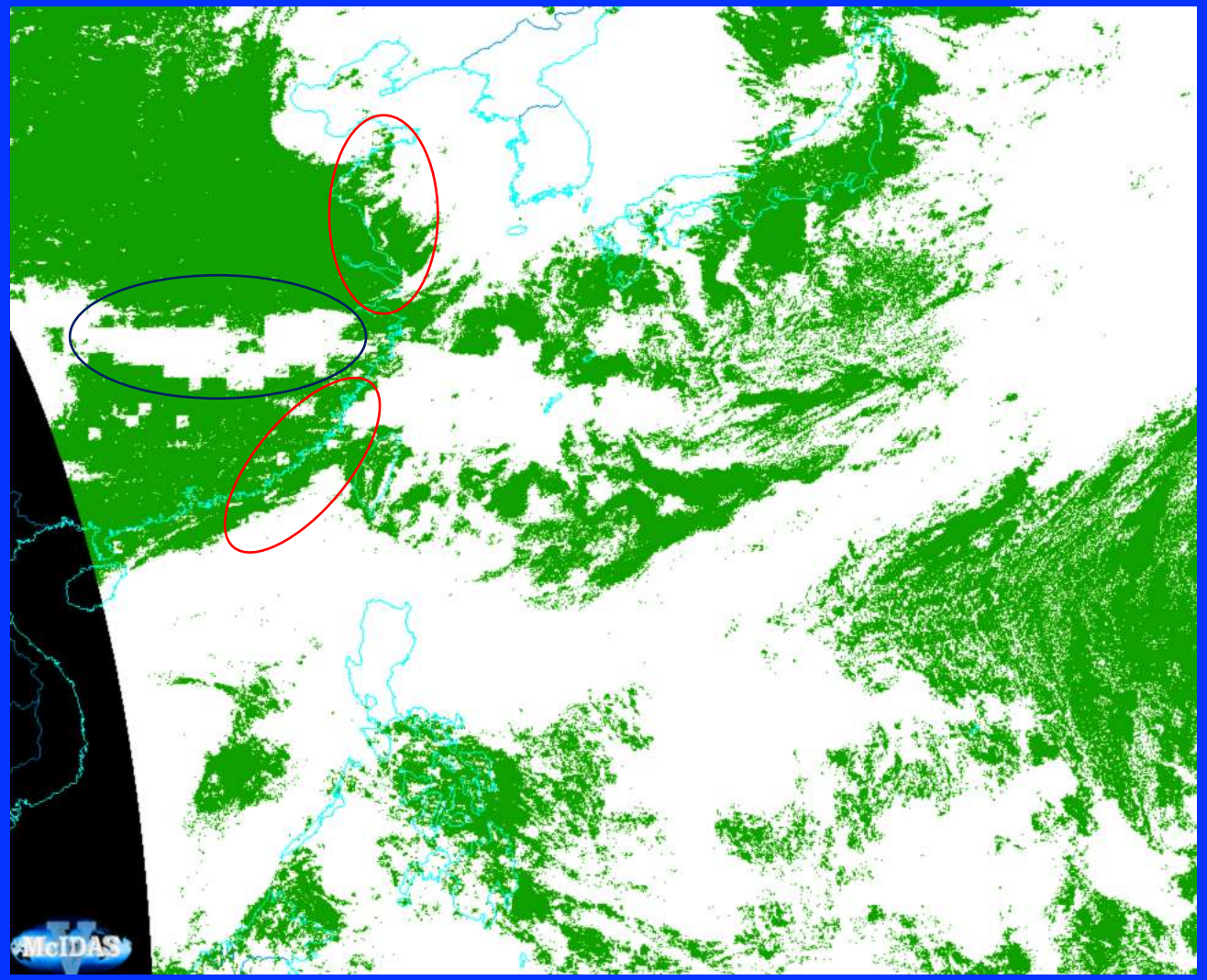
Daytime Himawari-8 Nov 10. 2019 0400Z



Ed5 GEO testing and refinement (cloud mask)

Himiwari-8 Mask (all-Channel); Daytime

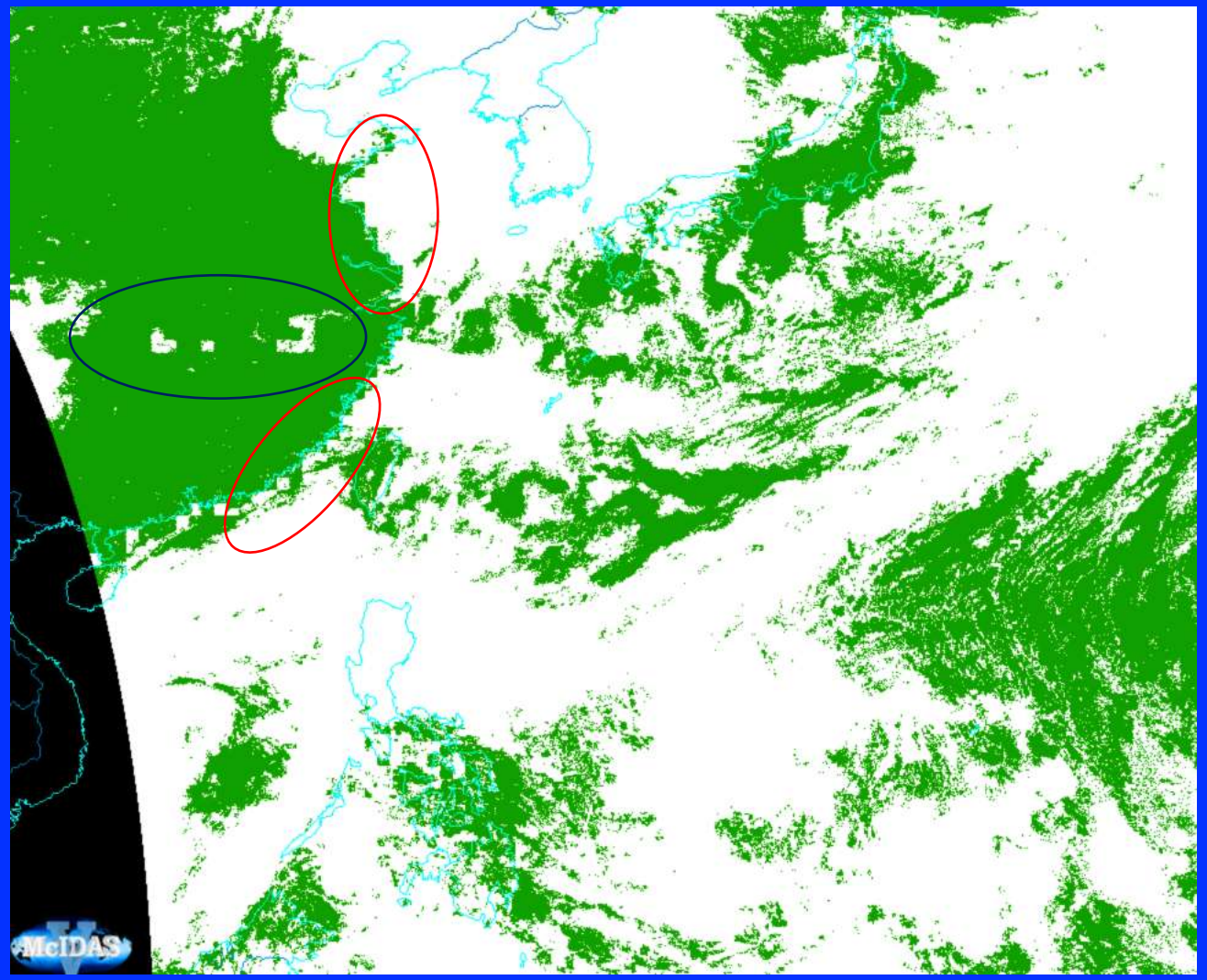
Ed5 GEO testing and refinement (cloud mask)



- Spectral signatures (not shown) suggest thin Cirrus over China

Himiwari-8 Mask (3-Channel); Daytime

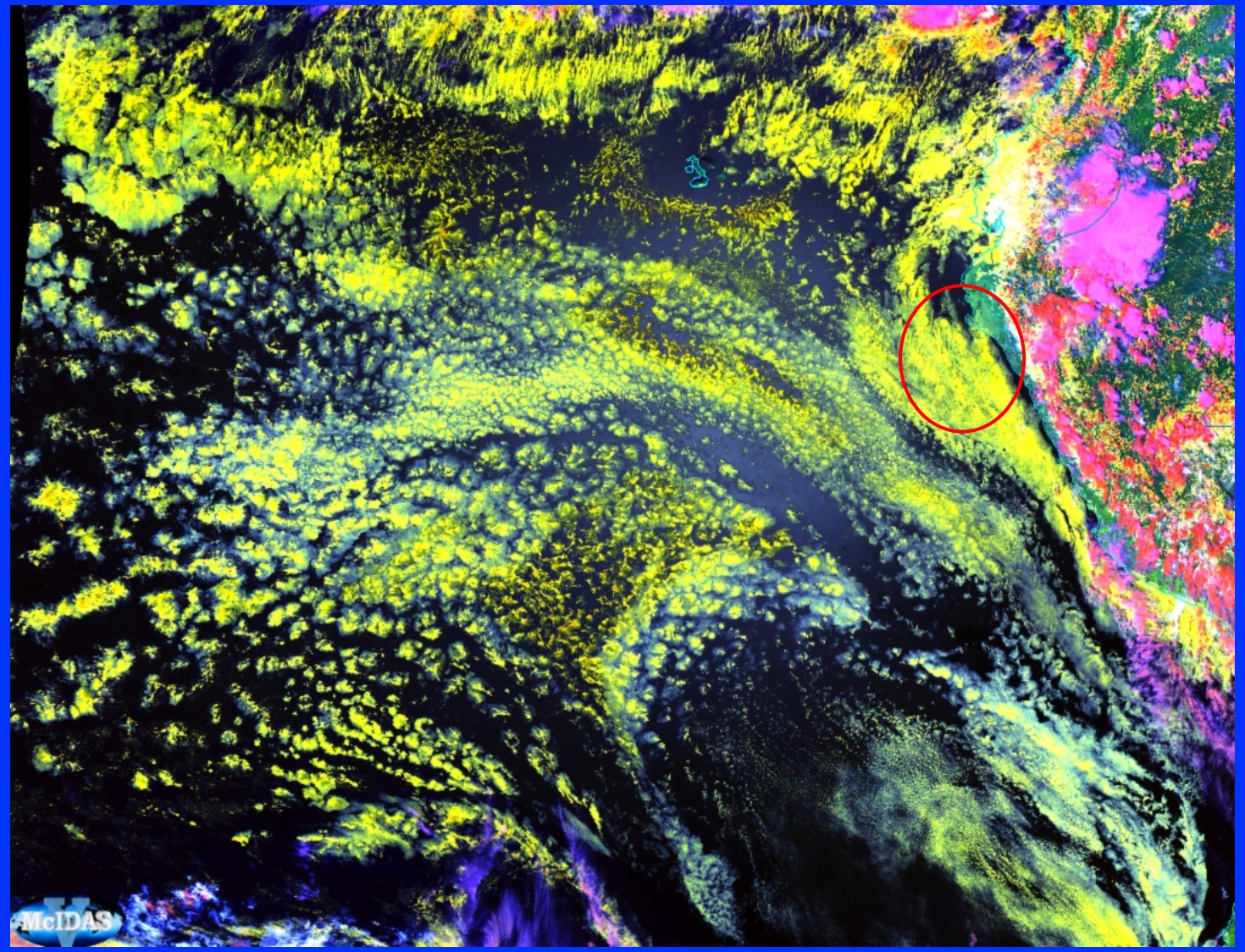
Ed5 GEO testing and refinement (cloud mask)



- Thin Cirrus over China harder to pick up with 3-channel method
- Pollution misclassified as clouds, some coastal chunkiness

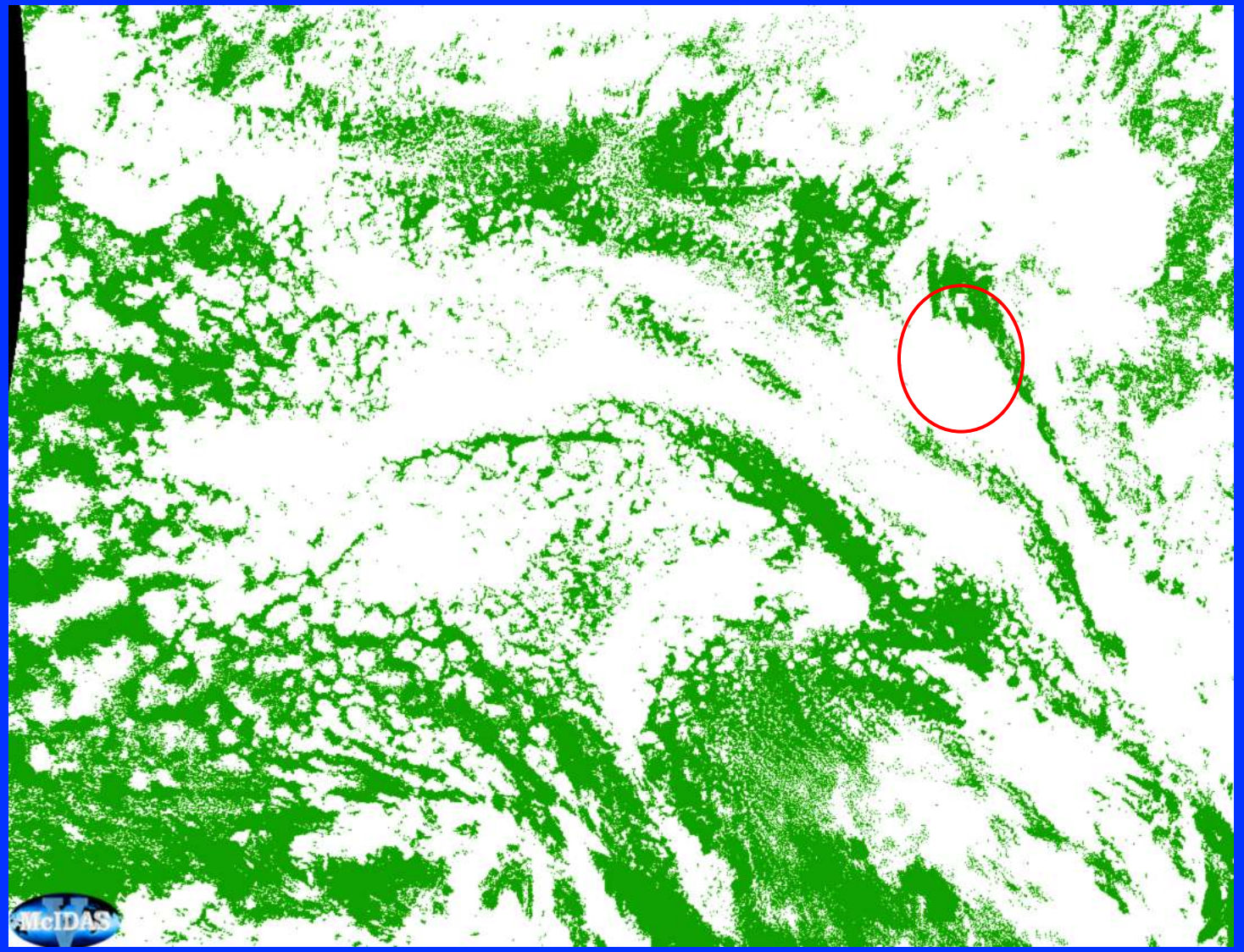
SH Sunglint GOES-16 Nov 11, 2019 1900Z

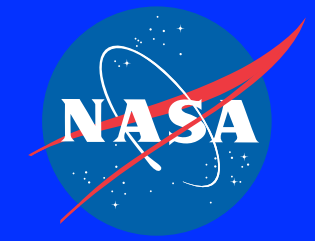
Ed5 GEO testing and refinement (cloud mask)



GOES-16 Mask All-Channel

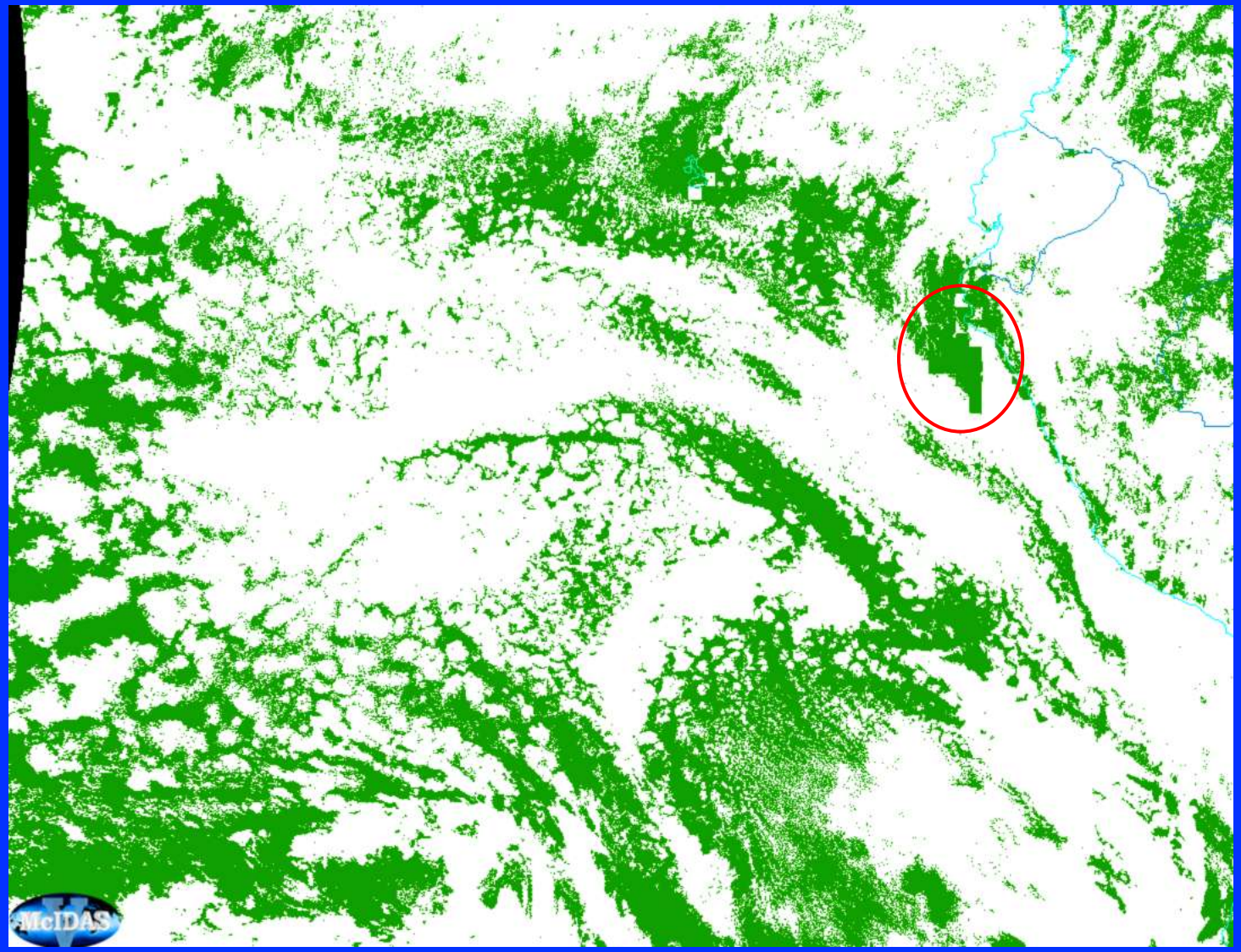
Ed5 GEO testing and refinement (cloud mask)





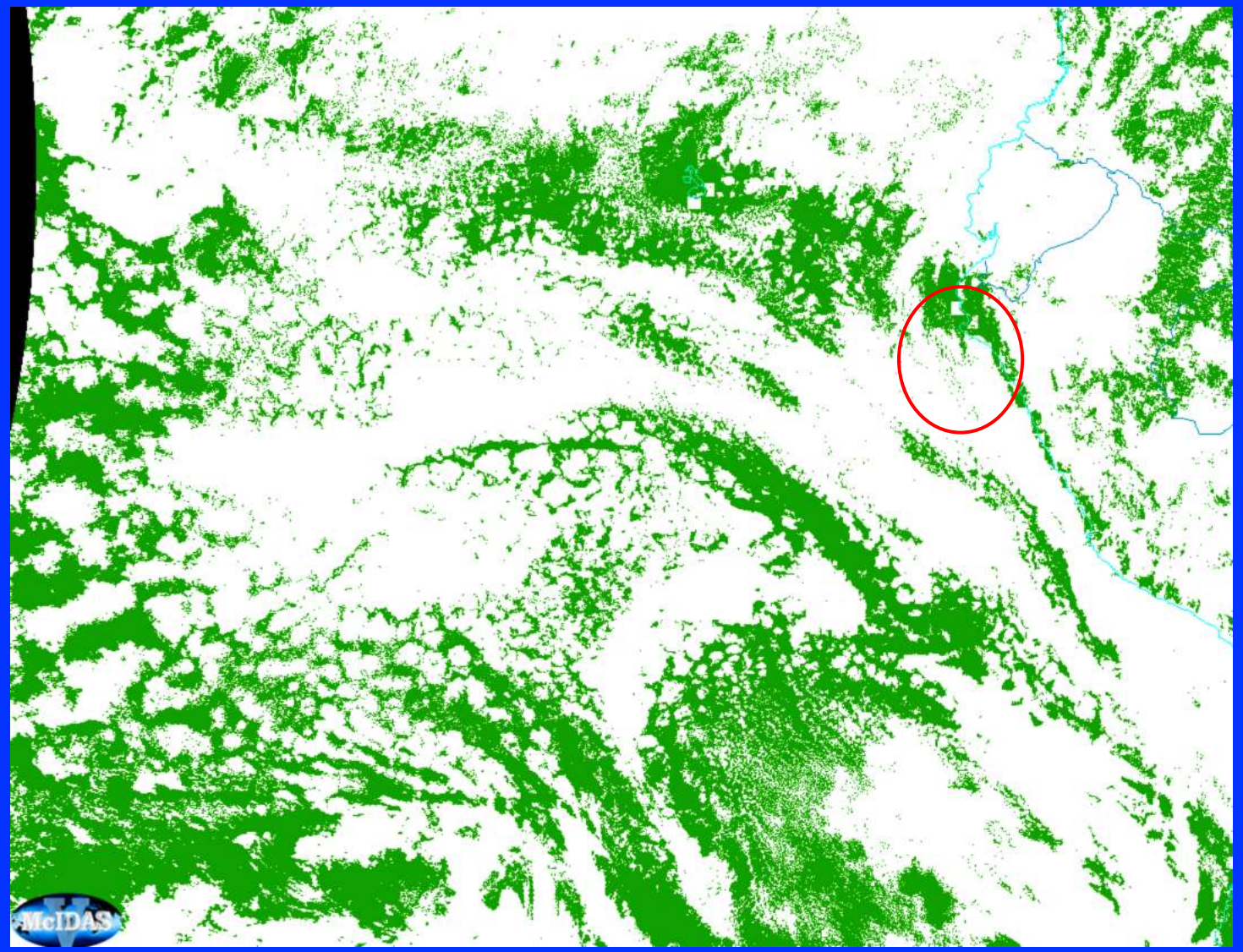
Ed5 GEO testing and refinement (cloud mask)

GOES-16 Mask 3-Channel

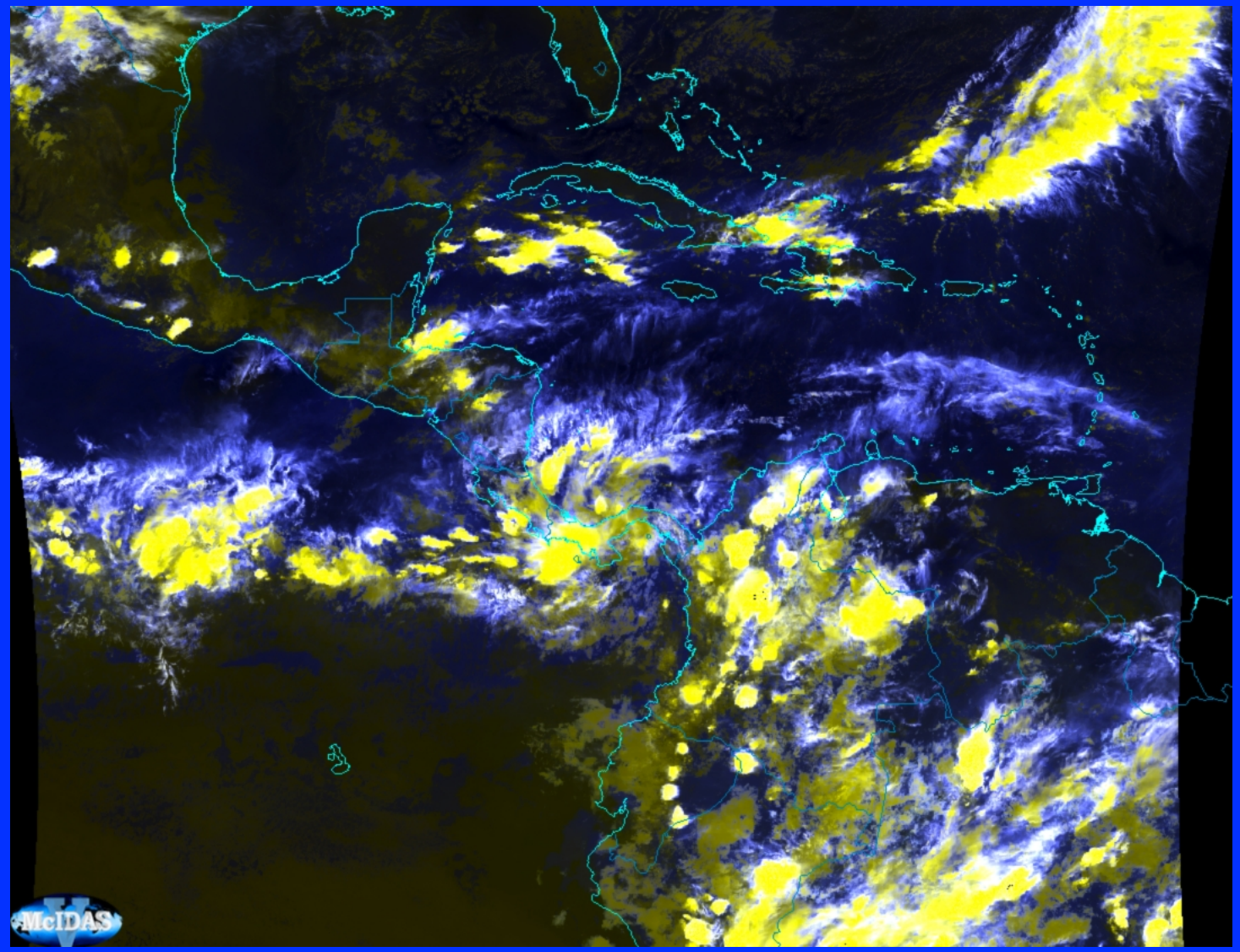


GOES-16 Mask 3-Channel New

Ed5 GEO testing and refinement (cloud mask)

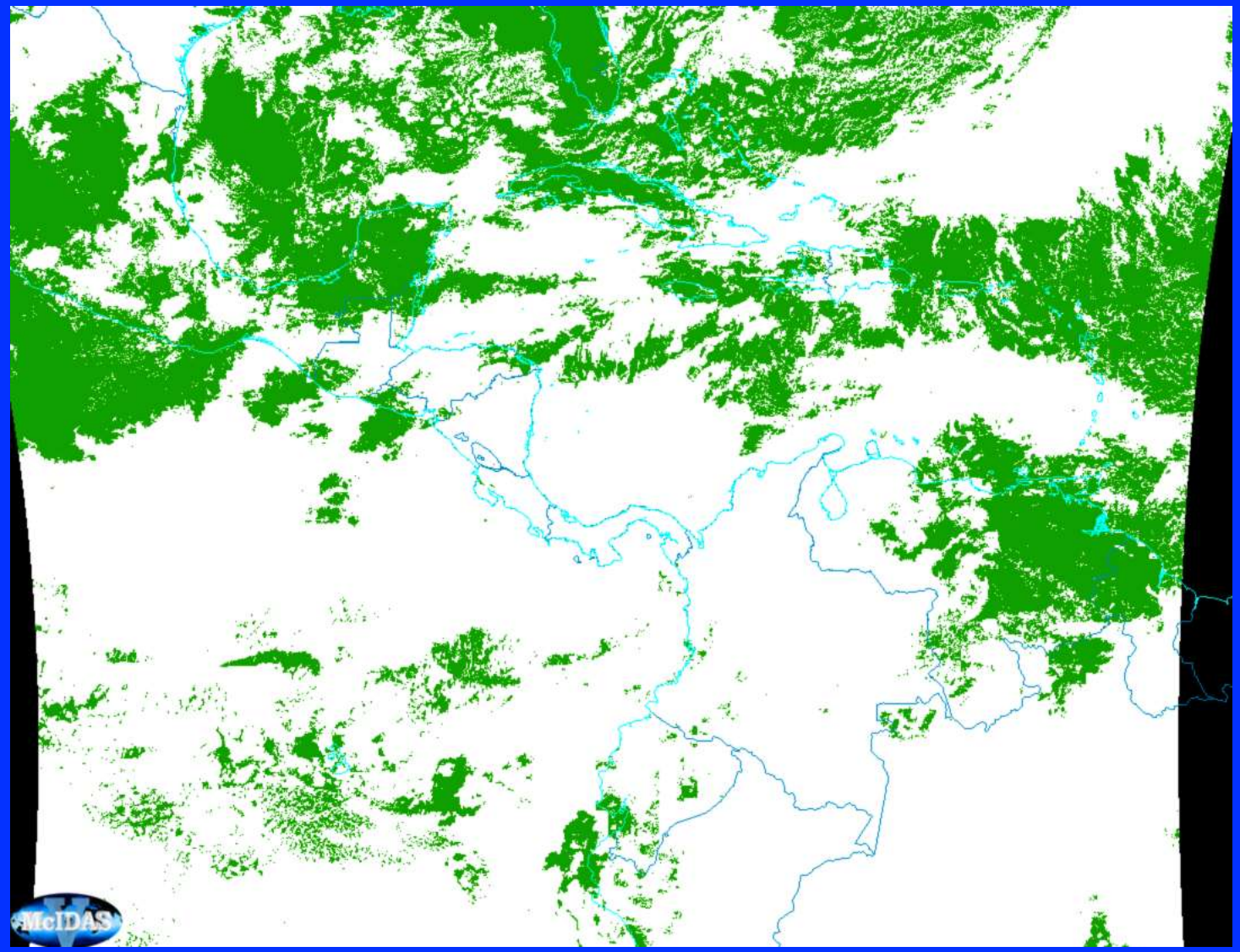


Night Tropical Ocean Nov 11, 2019 0300Z



Ed5 GEO testing and refinement (cloud mask)

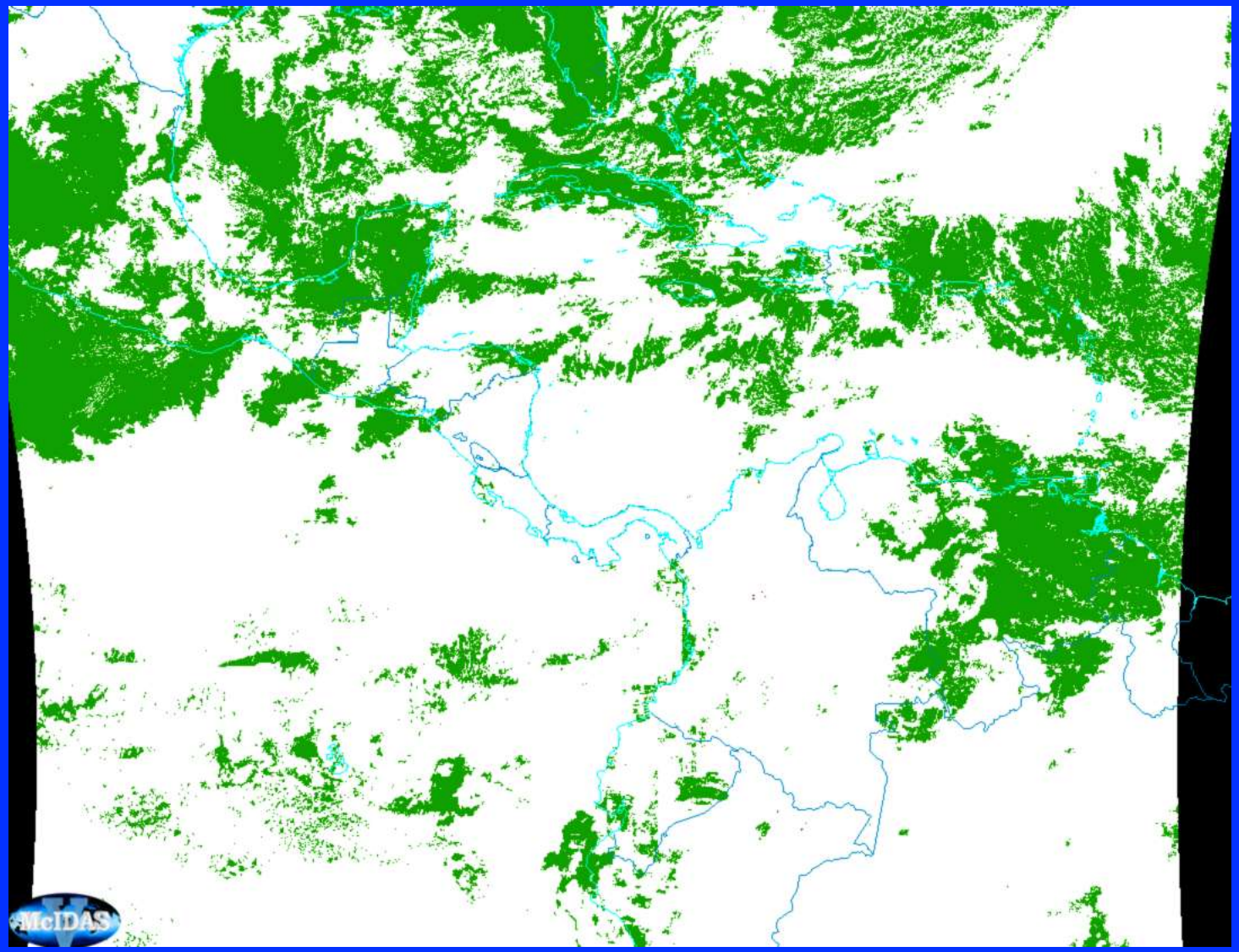
GOES-16 Mask All-Channel



Ed5 GEO testing and refinement (cloud mask)

GOES-16 Mask 2-Channel

Ed5 GEO testing and refinement (cloud mask)



- **Improved clear-sky analyses and further tuning to 2/3 channel cloud mask are works in progress**
- **Will look at retrievals next time; Daytime looks good. Some issues at night with bi-spectral method**

GEO UPDATE (GOES-17)

ABI cooling system not operating at capacity on the new GOES-17 satelllite

- Can degrade IR data or render it unusable for up to 6 hours at night
- Greatest impact during eclipse season near equinox's (~40 days?) when detectors are heated by direct sunlight
- Less impact near solstices but the problems persist at all times of year to varying degrees.

Impact to CERES: Measurements from most IR channels are unusable for variable lengths of time across midnight depending on time of year

Launch of GOES-17 aboard an Atlas V

Latest Channel Availability Information from NOAA

All Nighttime IR Bands used in CERES Ed4 GEO are negatively impacted except for band 7 (3.9 µm)

Band 13 (10.35 µm) and 14 (11.2 µm) now also in the yellow.

We have found band 13 to be mostly useable and critical for our mitigation strategy

ESTIMATED CHANNEL AVAILABILITY

Below is the current assessment of channel availability, **as of January 21, 2020**.
Note: This is a preliminary estimate that is subject to change as experts refine channel availability.

COLOR KEY:	Available 24hrs/day	Availability Exceptions

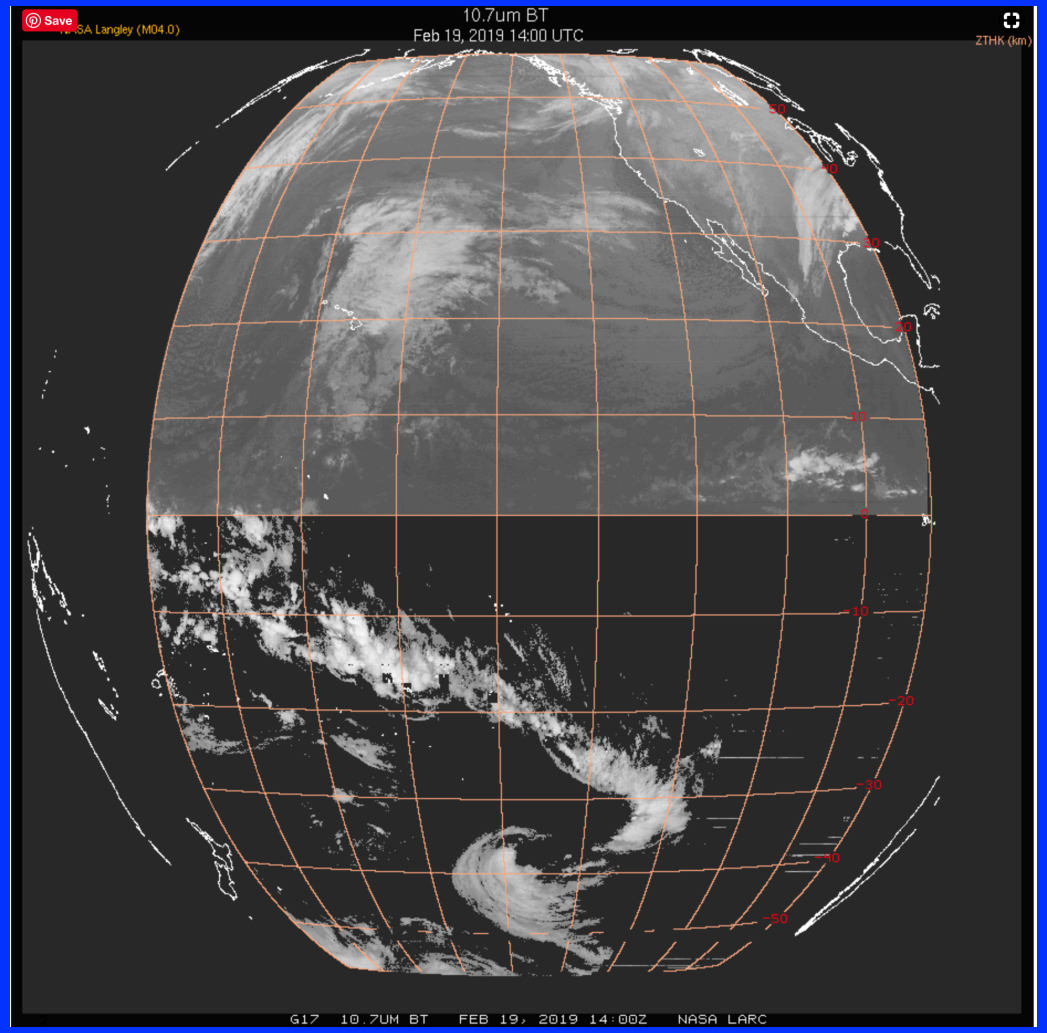
Tables scroll horizontally on smaller windows and devices.

CERES-GEO Nighttime Bands

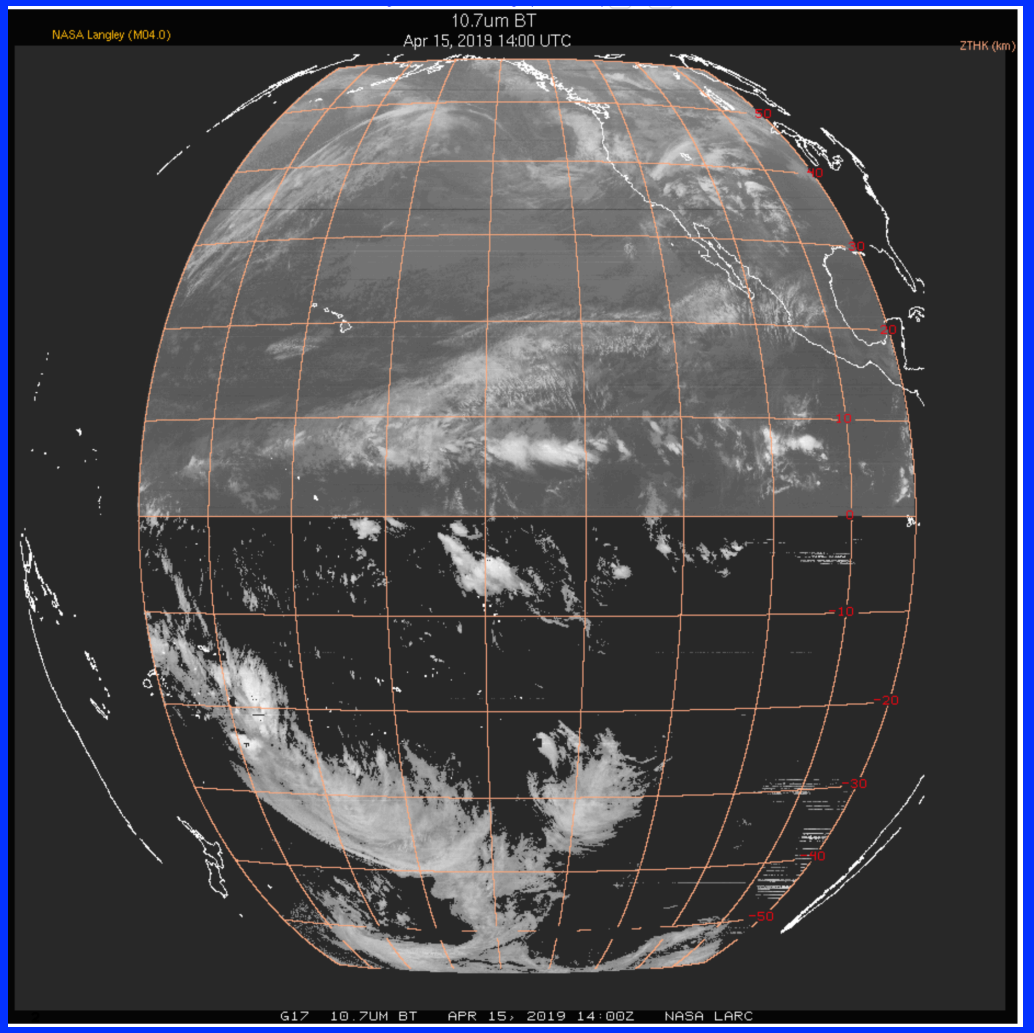
Band	Channel	Function	Estimated Unsaturated Signal Cold Season (Solstice)	Estimated Unsaturated Signal Warm Season (Pre-Eclipse)
1	0.47 µm	Blue	24 hr	24 hr
2	0.64 µm	Red	24 hr	24 hr
3	0.86 µm	Veggie	24 hr	24 hr
4	1.38 µm	Cirrus	24 hr	24 hr
5	1.61 µm	Snow/Ice	24 hr	24 hr
6	2.25 µm	Cloud Particle Size	24 hr	24 hr
7	3.90 µm	Shortwave Window	24 hr	24 hr
8	6.18 µm	Upper-Level Water Vapor	24 hr	16 - 17 hr
9	6.95 µm	Mid-Level Water Vapor	24 hr	17 - 18 hr
10	7.34 µm	Lower-Level Water Vapor	24 hr	16 - 17 hr
11	8.50 µm	Cloud-Top Phase	24 hr	19 - 20 hr
12	9.61 µm	Ozone	24 hr	16 - 17 hr
13	10.35 µm	Clean IR Longwave Window	24 hr	19 - 21 hr
14	11.20 µm	IR Longwave Window	24 hr	19 - 21 hr
15	12.30 µm	Dirty Longwave Window	24 hr	19 - 20 hr
16	13.30 µm	CO2 Longwave Infrared	24 hr	16 - 17 hr

Wide range of image quality impacts

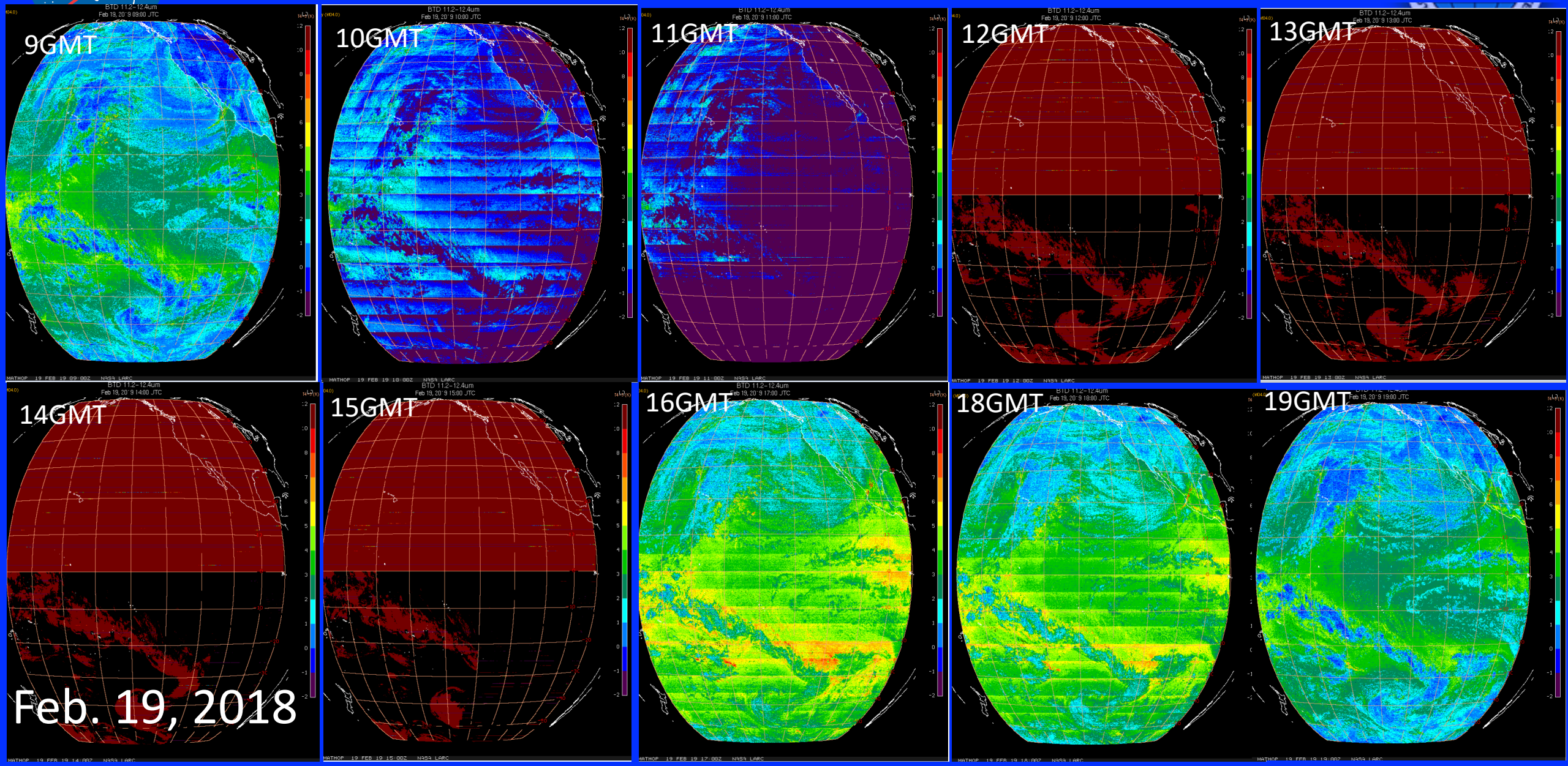
11µm BT, Feb 19, 2019, 14GMT



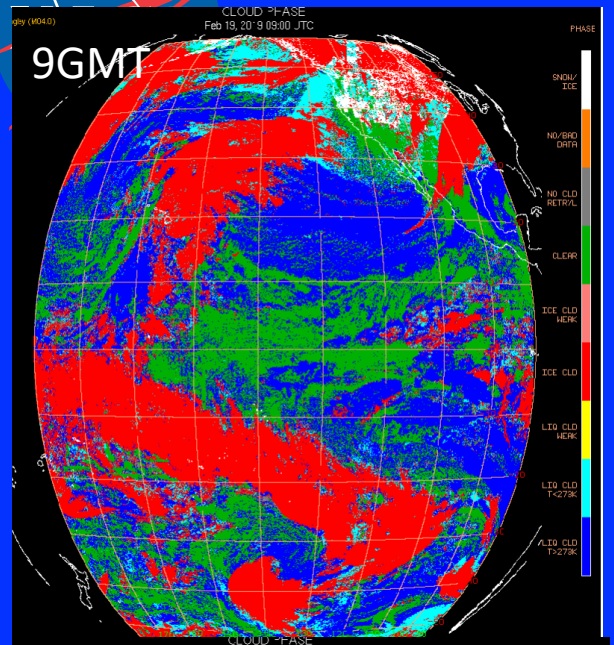
11µm BT, April 15, 2019, 14GMT

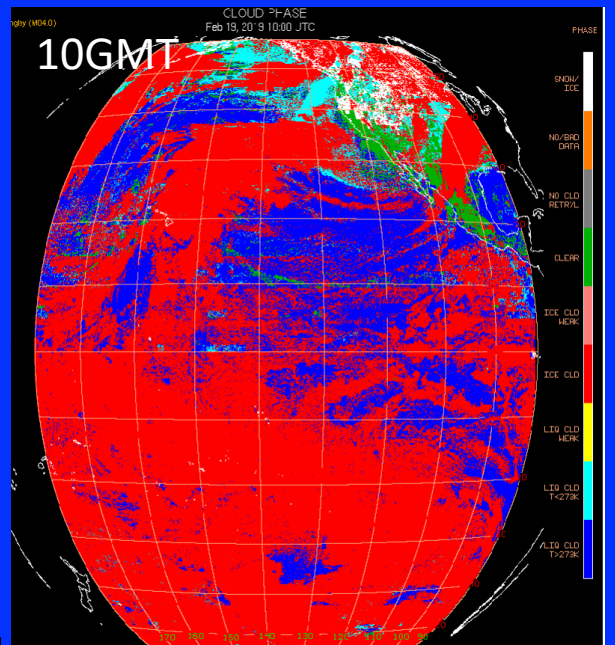


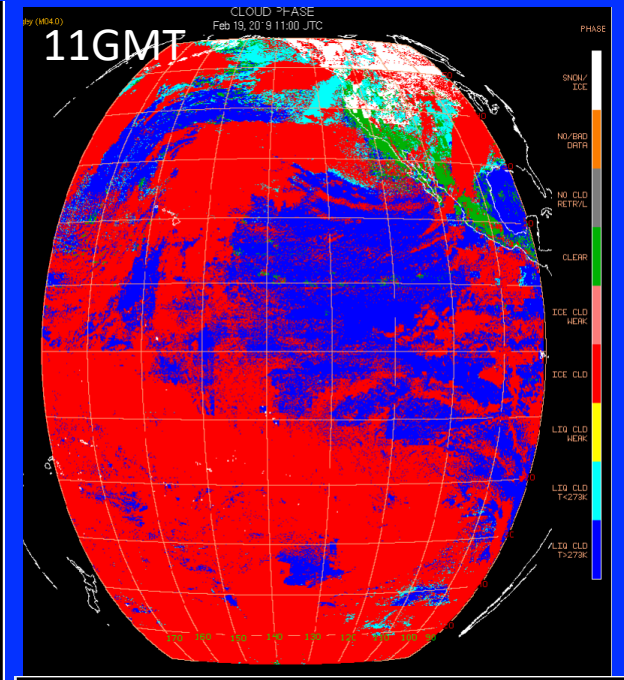
Example showing 11-12µm Brightness Temperature Differences

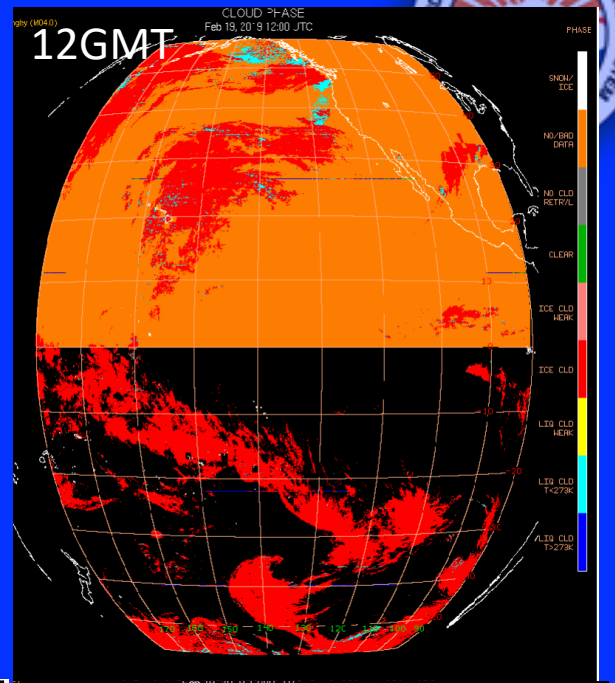


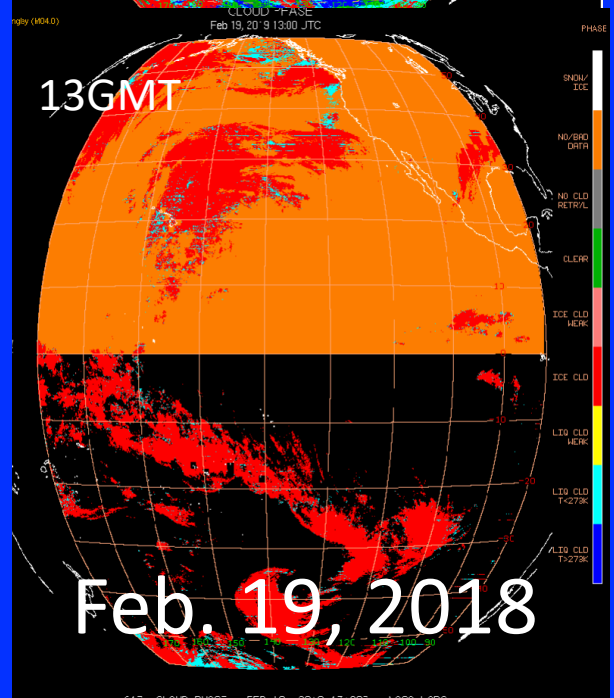
CERES-GEO DERIVED CLOUD TOP PHASE

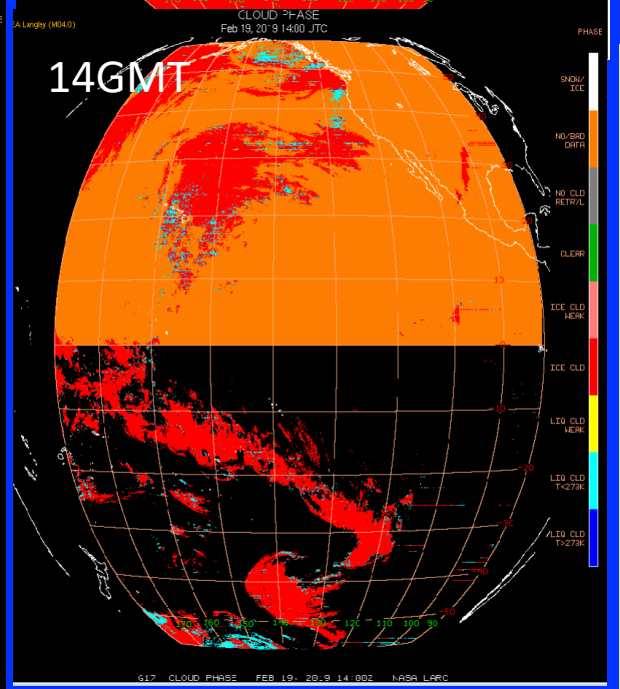


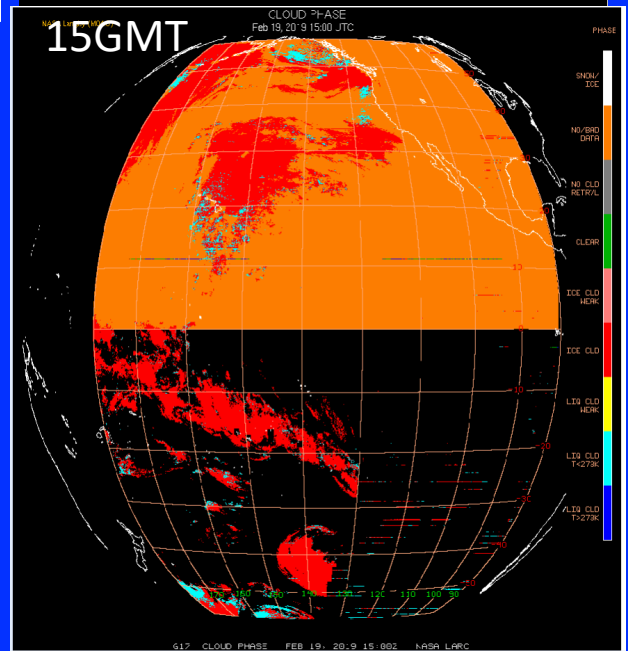


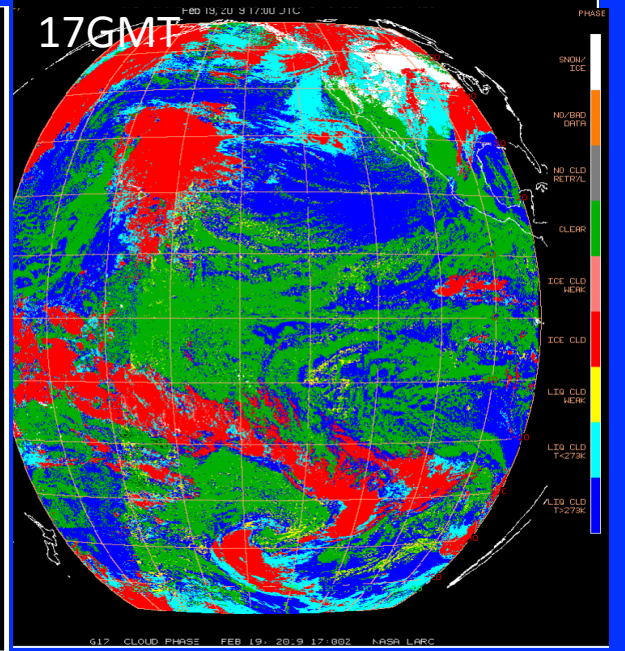












Feb. 19, 2018

GOES-17 Status for CERES

GOES-15 was decommissioned in early March

- GOES-17 data production for CERES will start with March 2020 data
- Goal for CERES Ed4 GOES-17 delivery is similar to strategy for Him-8 and GOES-16, i.e. deliver MODIS-like cloud retrievals using as many channels as possible
- GOES-17 code will be delivered by July 1 to meet CERES processing schedule
- Daytime cloud properties have been vetted & accepted by the downstream WG's

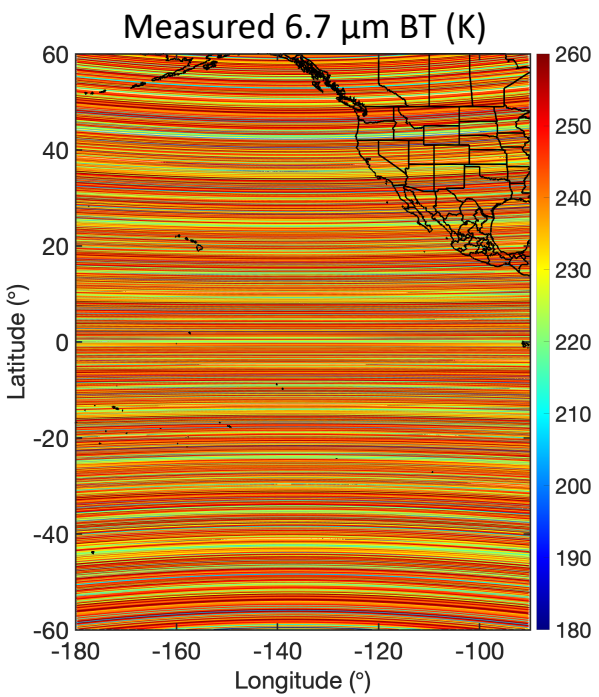
Plans for mitigating nighttime image degradation due to cooling issue

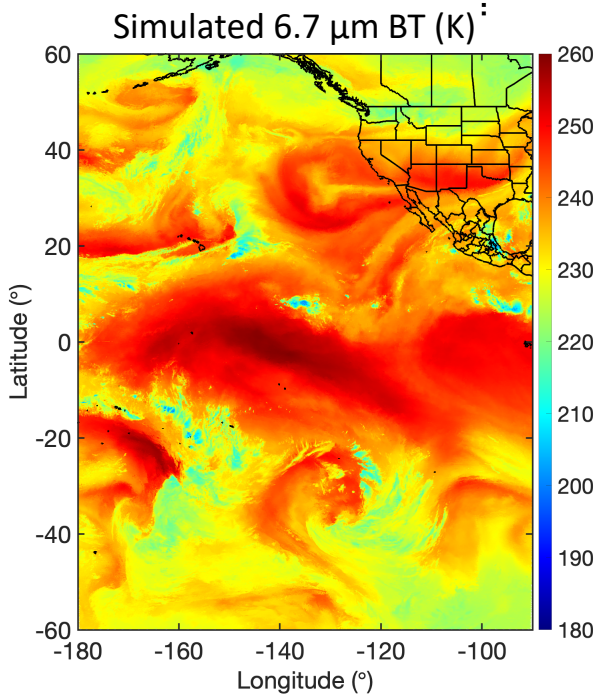
- Objective methods for flagging bad images in development and testing phase but it looks like more subjective screening procedures may be needed
- Employ one of two cloud retrieval options (decision still pending)
  1. Remove the hours with any bad data and fill with linear interpolation (TISA group)
  2. CWG will apply machine learning method using the good channels to extract more information…

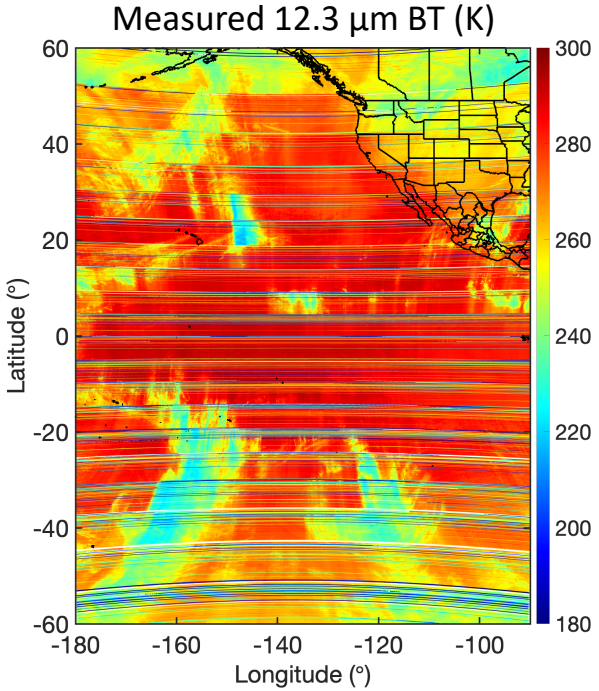
GOES-17 Status for CERES

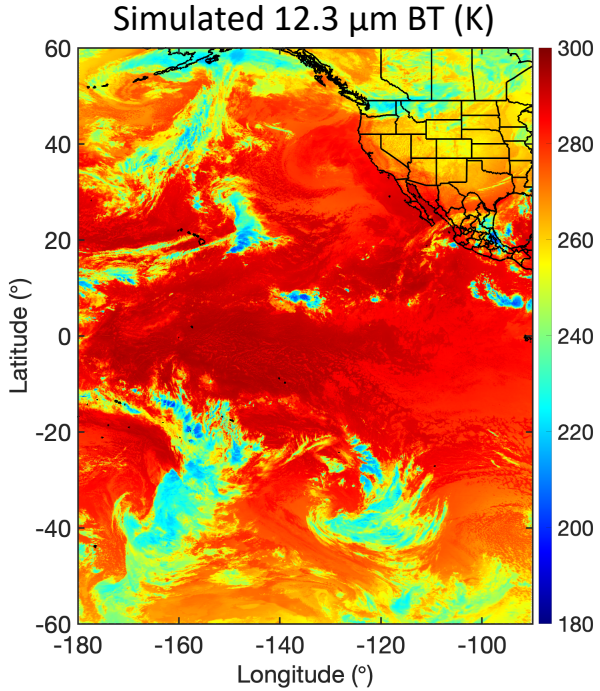
We have developed a 'Data Fusion' approach to extrapolate information from a previous good image time to a bad image time

- Uses two unaffected bands (U) at 3.9 and 10.4 µm to simulate radiances for the five affected bands (A) needed for the CERES Ed4 G17 cloud retrieval
- Utilizes U(A) relationships derived from an earlier hour when all 7 bands are good
- Method employs KDTree - multivariate nearest neighbor (NN) search algorithm
  - Developed by industry, highly efficient
  - Method has been demonstrated to create the missing 6.7 µm and 13 µm channels for VIIRS using CrIS data – i.e. make VIIRS more like MODIS (Weisz et al 2017)
- CERES CWG approach
  1. Generate KDTree relationships at 0930 UTC before cooling issues begin
  2. Apply KDTree and NN approach to create synthetic radiances for affected bands between the hours of 1030 and 1630 UTC
  3. Derive cloud properties from the synthetic radiances
- Since last STM, Fortran version now fully implemented in GEO processing system.





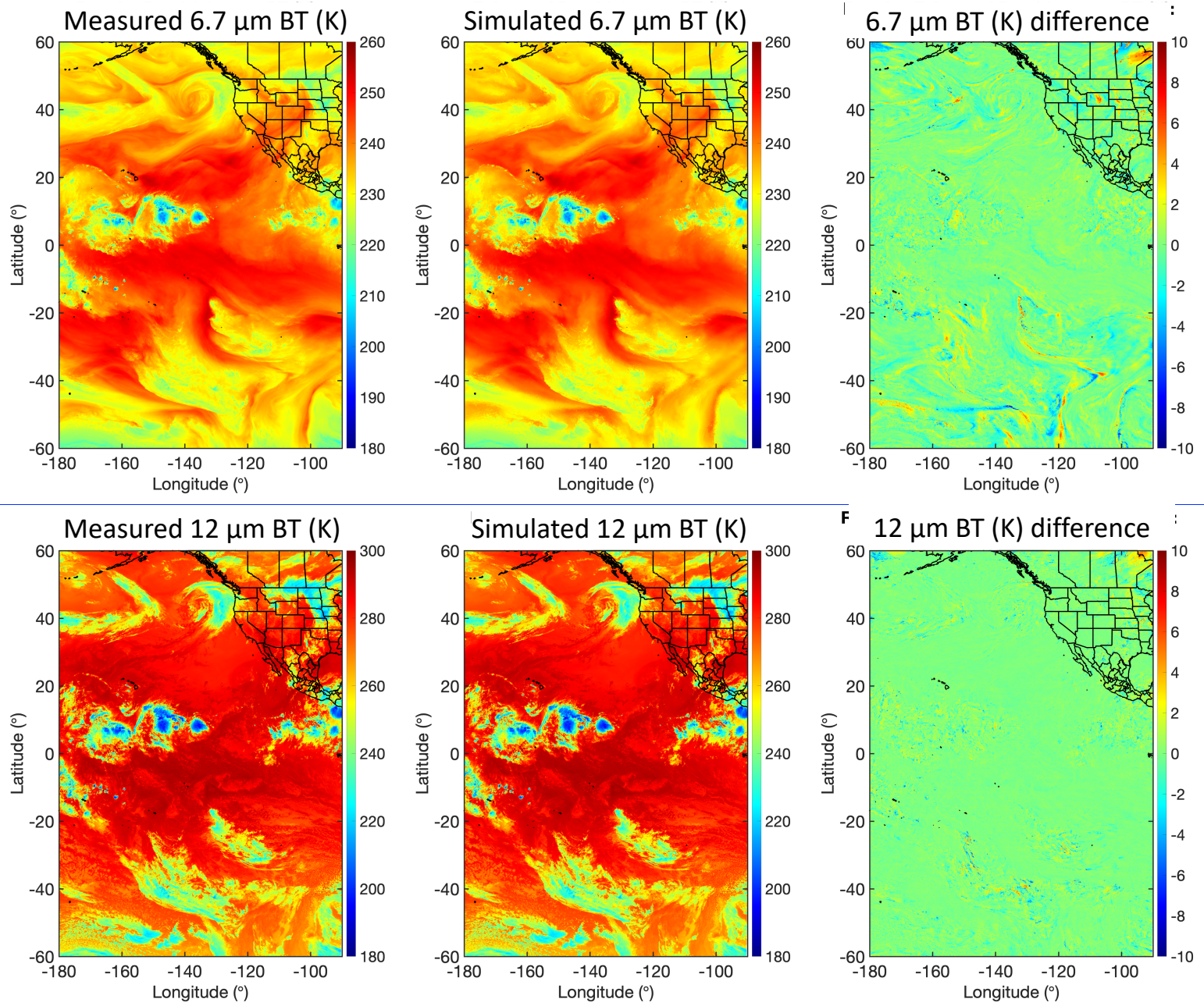




Data from 2019304
1230 UTC

Example of KDTree simulated radiances compared to corrupted imagery due to GOES-17 cooling problem during eclipse

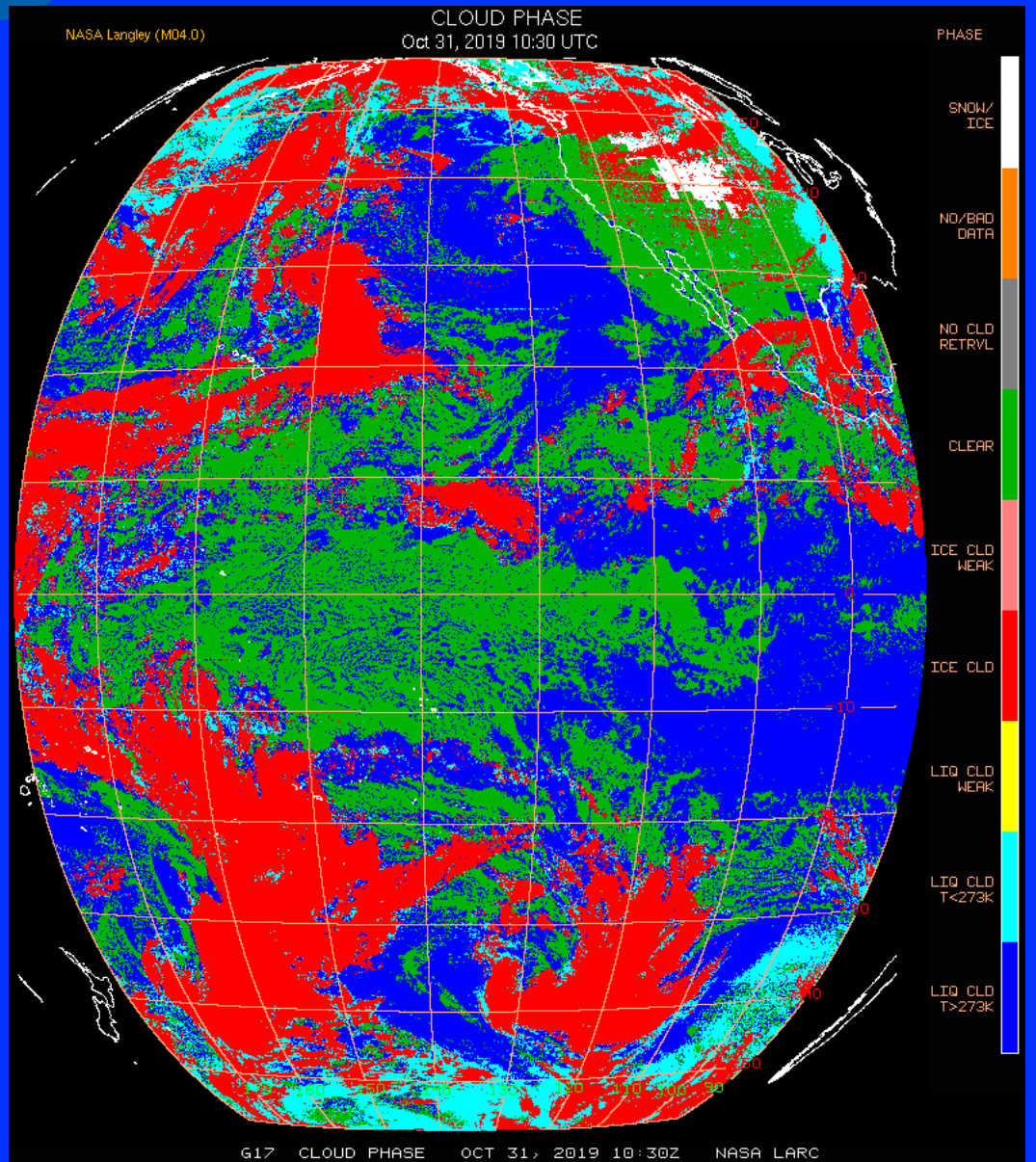
Data from
2019190
1030 UTC



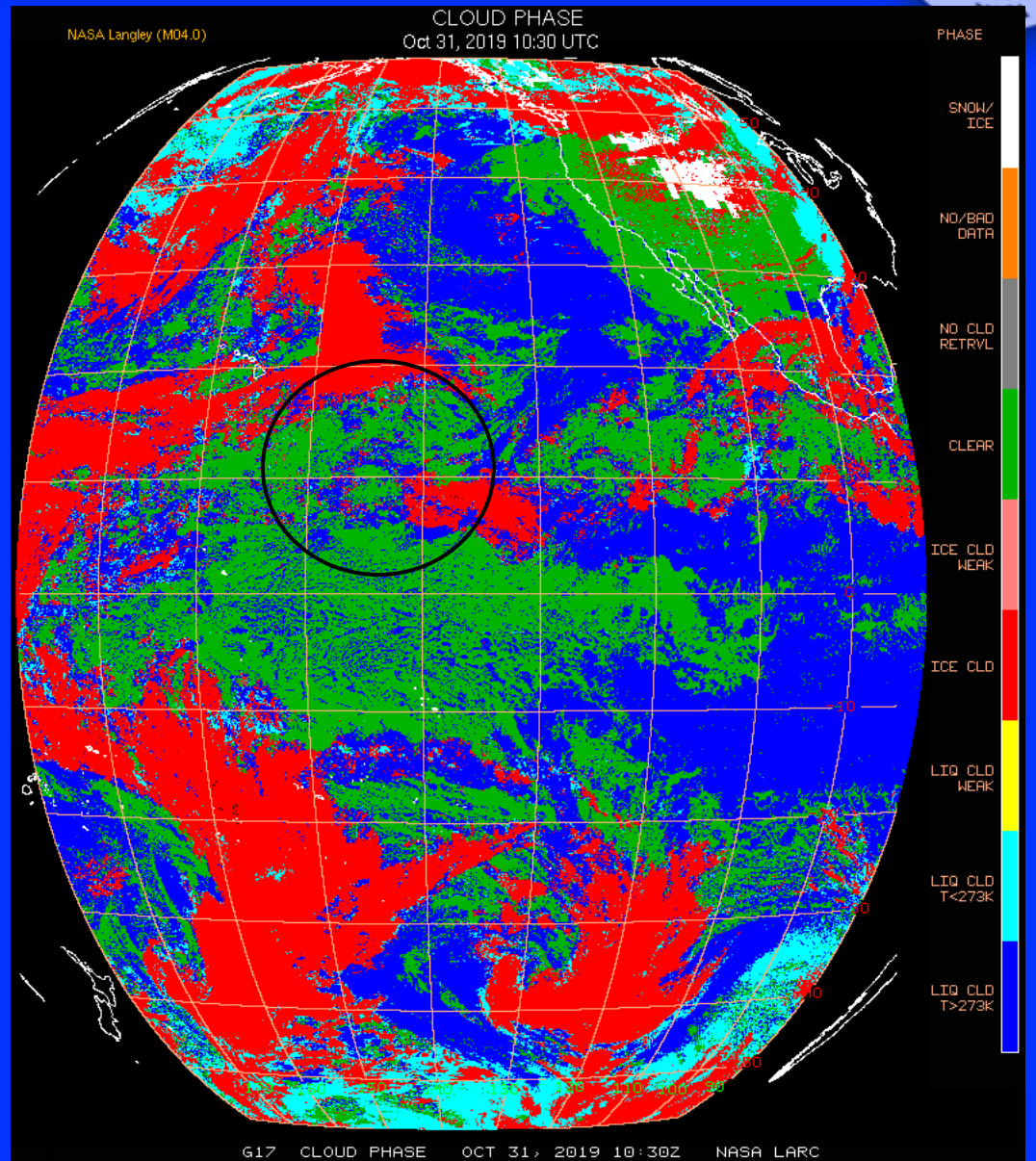
During periods of normal operation, i.e. no corrupted channels, the KDTree simulated radiances closely resemble the actual measurements

G17 Cloud Phase Comparison (Oct 31, 2019)

G17 SatCORPS R/T (from actual radiances)



G17 CERES GEO (from simulated radiances)

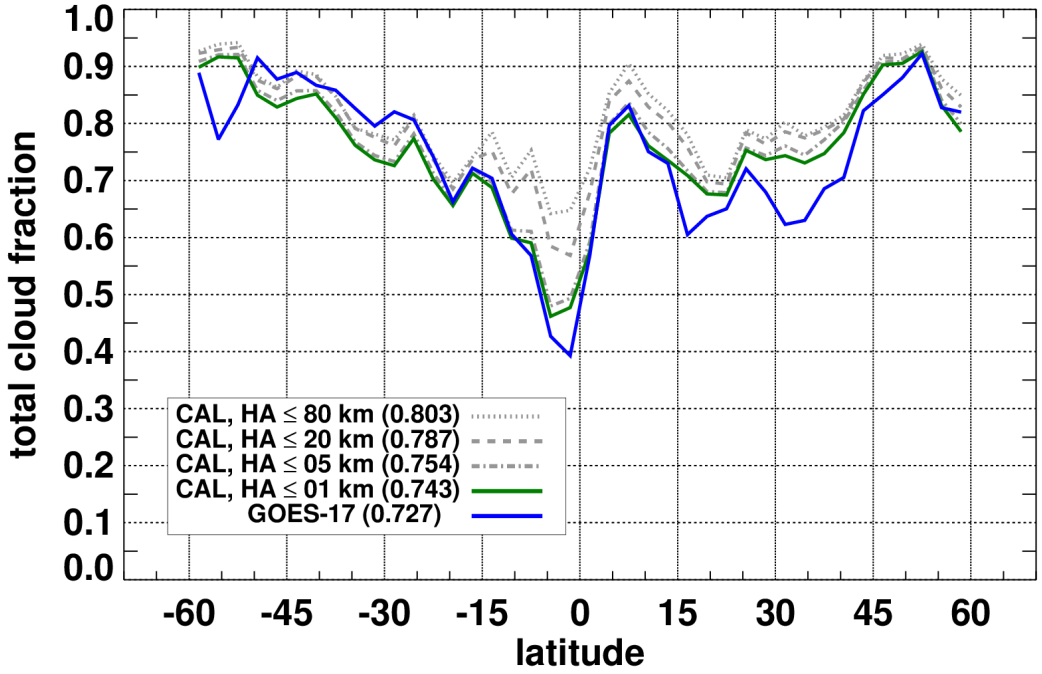


GOES-17 Validation with CALIPSO

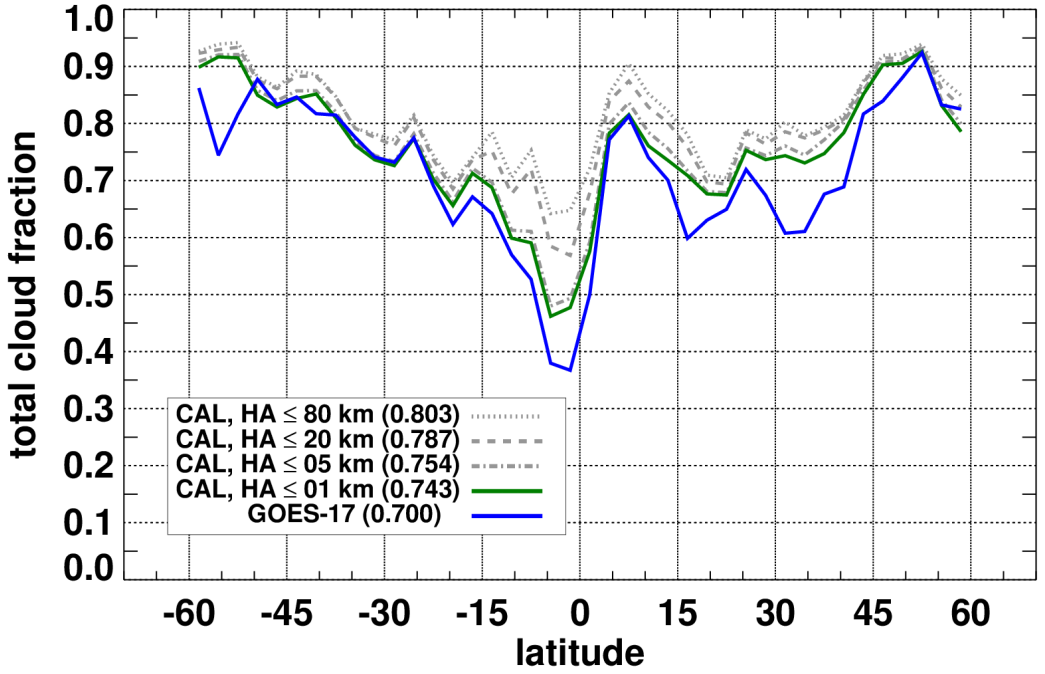
Total Cloud Fraction Comparison

Zonal Means (July 2019)

GOES-17 clouds from measured radiances



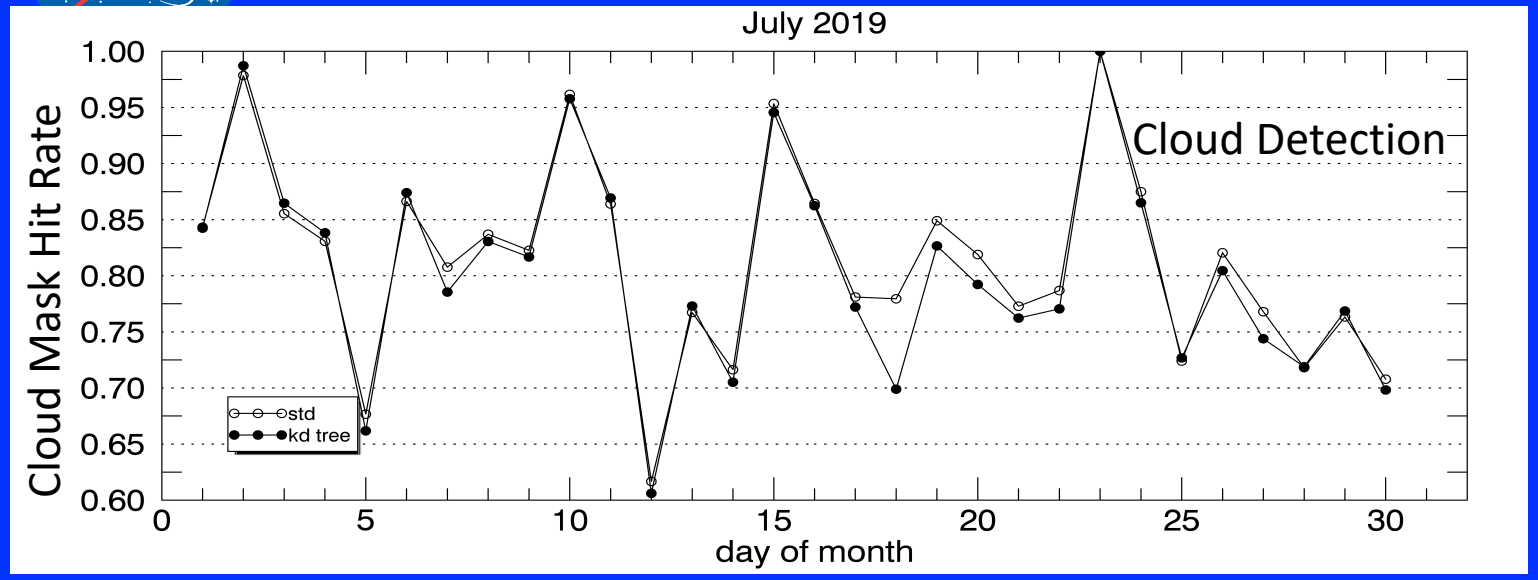
GOES-17 clouds from simulated radiances

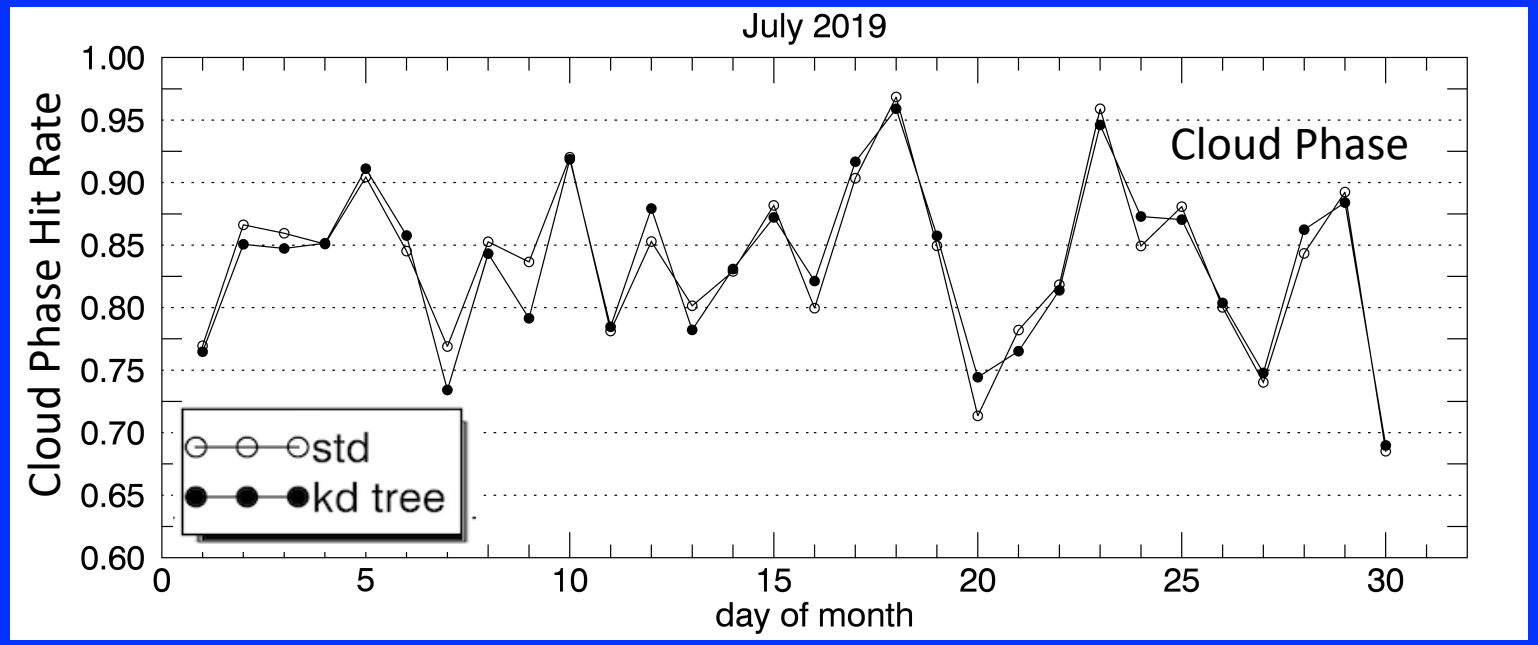


*note, this version did not exclude some bad image hours

KDTree more accurate in this assessment

GOES-17 Validation with CALIPSO





Cloud Detection and Cloud Phase Hit Rates

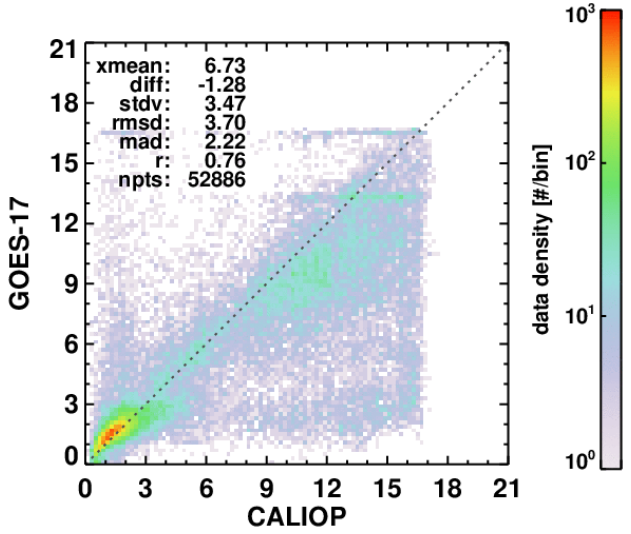
*Bad images near local midnight excluded

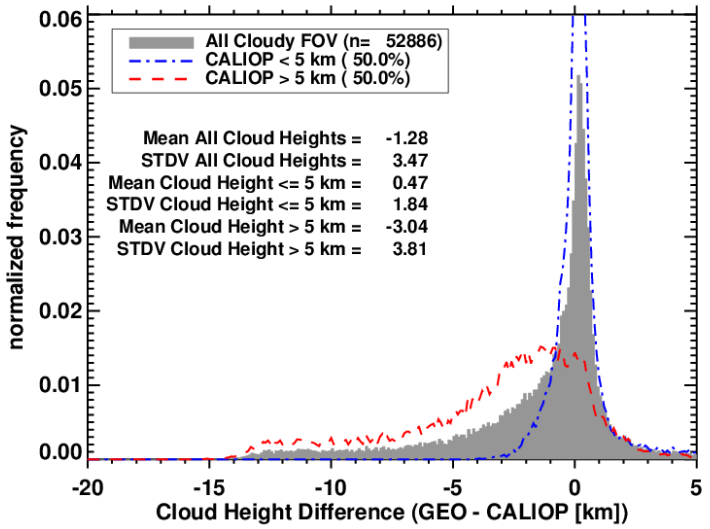
Nighttime cloud properties derived from simulate radiances simulated are very comparable in accuracy to those derived from measured radiances

GOES-17 Validation with CALIPSO

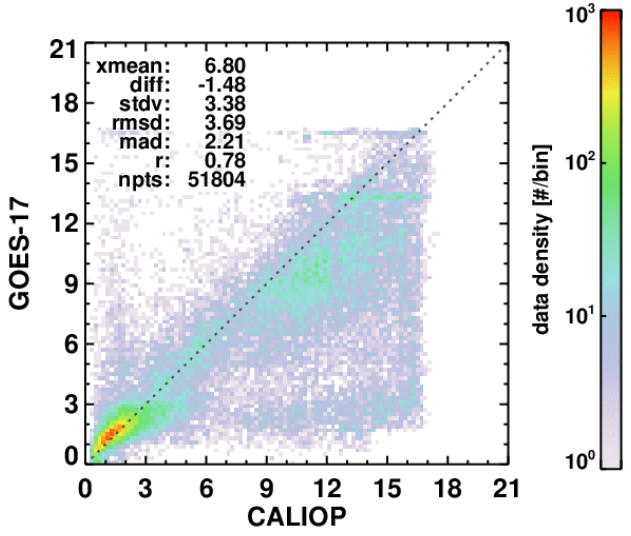
July 2019

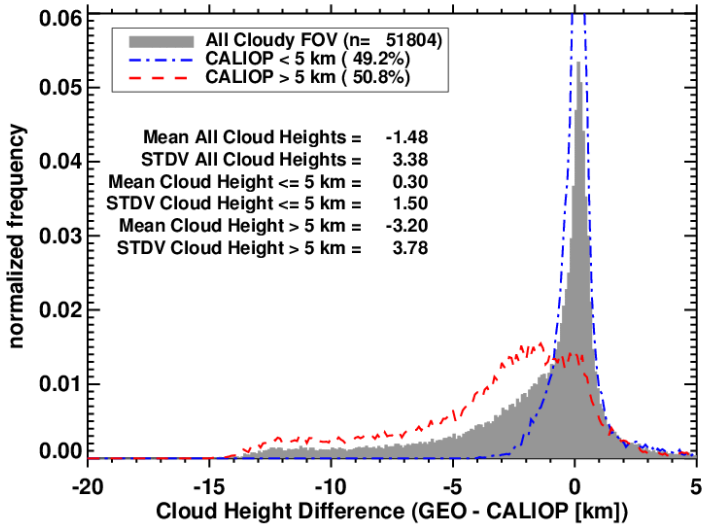
Derived from radiance measurements





Derived from simulated radiances





Cloud Top Height Comparison

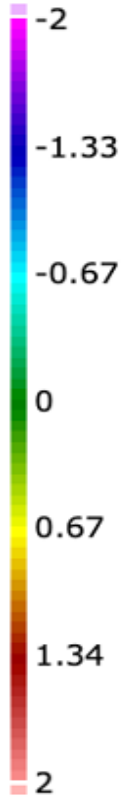
Accuracy also very comparable

Impact on LW flux Derived in CERES-TISA

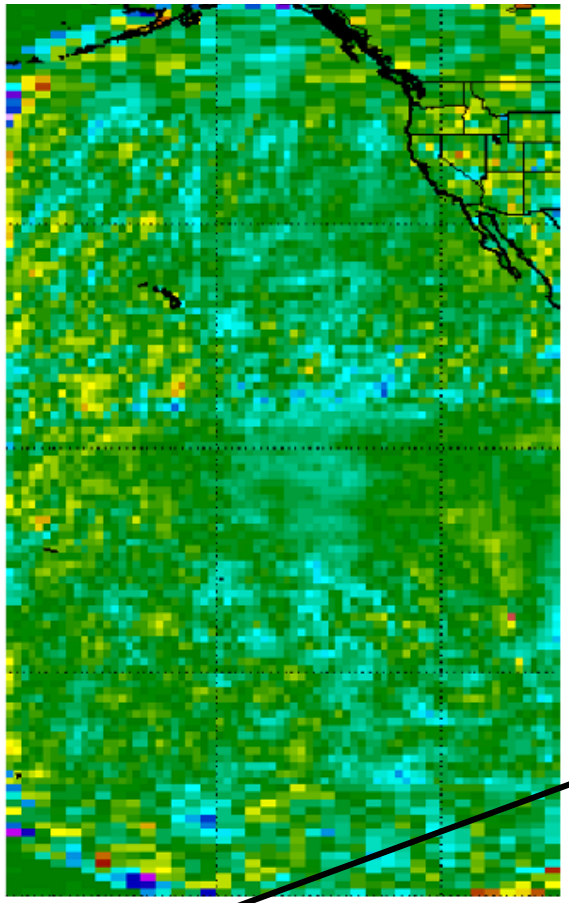
GOES-17 minus GOES-15 LW flux

Oct 2019

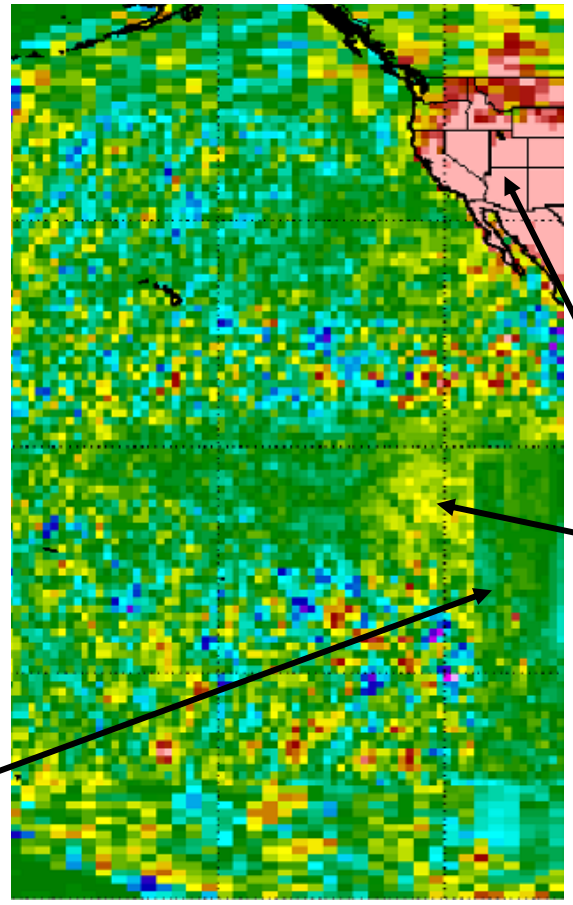
LW flux (Wm-2) difference



KD tree



Temporal linear interpolation



- KDTree method provides the WV (6.7µm) and window (11.0µm) channel radiances for the LW NB to BB algorithm
- The linear interpolation method simply interpolates the LW flux from 9:30 GMT to 17:30 GMT
- **The KDTree method is much more consistent with GOES-15**
  - **LW flux is less noisy**
  - **More accurate nighttime LW fluxes over land as well as over stratus regions**

GOES-17 also fills in this regions, which is currently filled in with GOES-East or 16

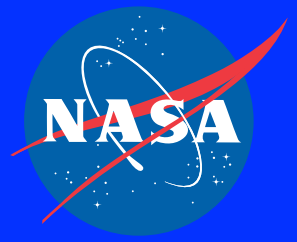
GOES -17 Summary

- Cloud parameters derived from simulated imagery look very good
- Nighttime cloud properties challenging to begin with – loss of accuracy minimal
- CWG recommends adopting this approach
- May still require removal of some very bad hours that affect 10.4 µm near the equinoxes

Next Steps

- Still have some bad scan lines creeping in, further work needed to resolve
  - Testing objective methods, routine subjective screening by analyst may be needed
- Re-evaluate single channel (3.9 µm) simulation approach (drop 10.4 µm)
- Further testing by downstream working groups in progress

CWG on schedule for July delivery


NASA


CLOUDS AND THE EARTH'S RADIANT ENERGY SYSTEM
CERES
NASA

QUESTIONS ?